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A 120,000 kw. Hydro-Electric Power Development with 4000 ft. Head*

One of the most interesting hydro-electric power developments under way at the present time in this country is that of the Pacific Light & Power Corporation and known as the Big Creek project in Fresno County. It is interesting because of the large amount of power to be developed from a comparatively small amount of water at a high head and because it will have the longest radius of transmission and the highest line voltage of any plant in the country when completed.

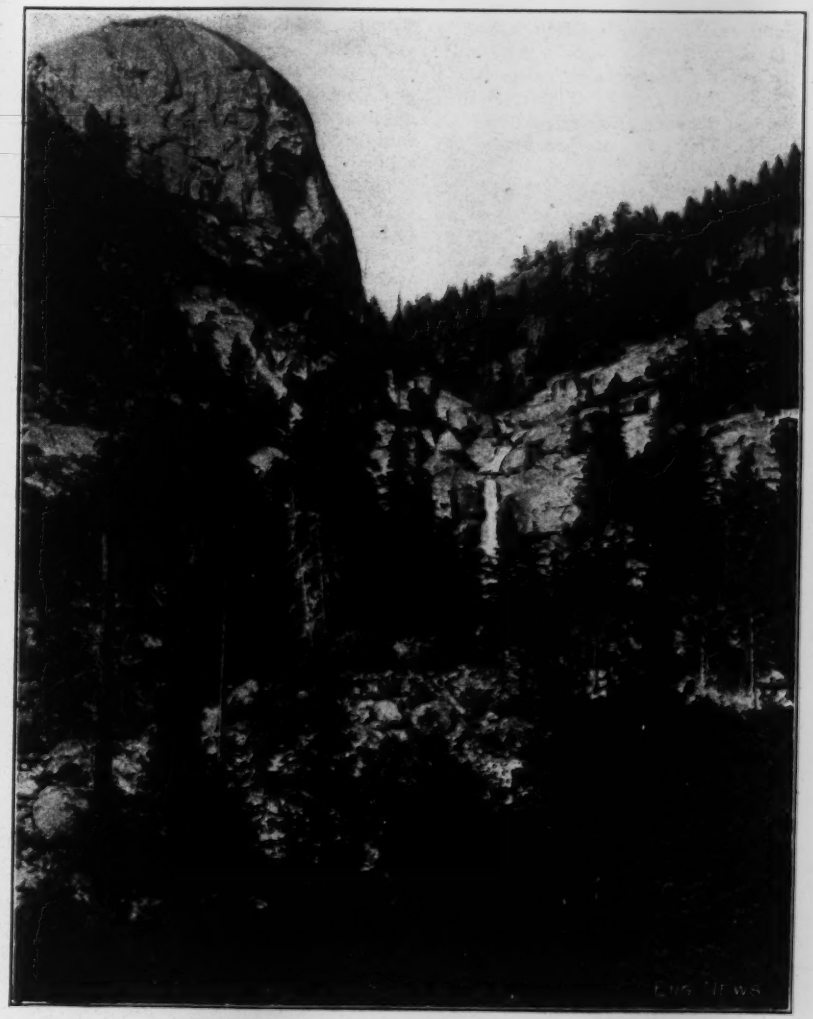
This company has its main offices in Los Angeles, Calif., and operates a system comprising six hydro-electric and three steam generating stations, having an aggregate capacity of some 70,000 kw. Seventeen towns and cities in southern California, having a population of about 750,000, are supplied. The operating data of the company have shown that the cost per unit of power output is about four times that of the steam plant over the hydraulic; including the cost of transmission, the unit cost of power delivered from the hydraulic plant is about one-third that from the steam.

HYDRAULIC DEVELOPMENT—Big Creek lies in the Sierra Nevada Mountains about 70 miles northeast of the city of Fresno and approximately 270 miles from Los Angeles. The stream originates in high snow-capped mountains. At a short distance above the main falls, where the power development is to be undertaken, is a natural basin which may be converted into a storage reservoir having a capacity of about 100,000 acre-ft. The walls of the basin are comparatively low on the south and west sides and high on the north and east, the latter forming part of the Sierra divide which runs up to elevations of 10,000 and 11,000 ft. with very little below 9000. Under these conditions warm, southwest, moist winds pass up against the higher divide and precipitate a large portion of their burden in the basin and the drainage area of Big Creek.

The water shed of this stream has an area of about 80 sq.mi., all of which is above 6800 ft. elevation. The annual rainfall over the whole area is usually in excess of 80 in. per year and the run off is equal to about 50 in. Big Creek drops rapidly after leaving the natural basin mentioned and within six miles' course there is a drop of about 4000 ft., all available for power development. On the basis of the figures given, an average daily flow of 295 cu.ft. per sec. would be expected, from which about 98,000 hp. or 73,000 kw. could be expected to be developed with machinery of ordinary efficiency. The expected capacity of 120,000 kw. then is a peak-load capacity based on a 50% load factor.

The small amount of water for the large amount of power is seen in the accompanying figure, although it is probable that the effect is somewhat distorted by the deceptive distances. With the amount of storage available it is believed possible to operate the plant for 150 days on storage alone.

The water will be impounded by three large gravity-section concrete dams, 165 ft., 100 ft. and 100 ft. high, respectively. These will be built on solid granite for-



BIG CREEK FALLS; SIERRA FOREST RESERVE

*Arranged in part from information supplied by the Stone & Webster Engineering Corporation, 147 Milk St., Boston, Mass.; in part from information secured from the U. S. Dept. of Agriculture.

mation and will close the natural openings of the storage basin. All material for construction, except cement, is close at hand.

Water will be first taken from the reservoir through a 400-ft. tunnel in solid granite provided with rack bars and head gates at the intake. From the outlet the water will flow 6800 ft. through a steel pipe to the penstocks which drop 2100 ft., vertical distance, to power house No. 1.

The tail water from this plant will be guided to a second tunnel, the forebay of which will be made from the natural bed of the creek by constructing a dam 70 ft. high and provided with a spillway; rack bars and head gates will be placed at the intake. This second tunnel will be 2100 ft. long and through solid granite. At the tunnel outlet, the water will pass directly into the penstocks of power house No. 2, and these drop approximately 1900 ft. vertical distance. The tail water from plant No. 2 will be returned to the old course of the creek.

It should be noted that the forebay of the second tunnel is below the junction of a second small stream known as Pitman Creek. The amount of water added by this will about compensate for the difference in head of the two power houses, so that each will develop the same capacity.

POWER STATIONS—Each power station is designed for a capacity of 60,000 kw. in four units, only two of which will be installed at present. Two overhung impulse-wheels will be mounted on one shaft to drive a three-phase, 6600-volt, 7500-kv.a. generator. The station building will be of reinforced concrete and the equipment is designed to secure every assistance for continuous operation.

RAILROAD—The site of this development is in a rugged country some 50 miles from a railway, so that transportation of the 50,000 odd tons of cement, structural material, machinery, and supplies for the initial development presented a problem. The usual method of this district, freighting with 12- and 14-horse teams, was decided to be out of the question on account of the time required and because of the excessive cost—the winter rate being $20 per ton. Therefore, 56 miles of standard-gage railway was first built from a point on the Southern Pacific 22 miles north of Fresno to the site of power house No. 1. Here a railway yard was laid down and connected with a standard-gage incline hoist to the basin above. After the basin was reached seven miles of construction track were built connecting with the various dam sites, gravel pits, storehouses, and sub-camps. Under this arrangement material can be delivered directly by rail to any part of the work.

The railroad was built for about half of the distance of a private right-of-way—up to the point where the Sierra National Forest Reserve was reached. Two divisions of the road have been created, one within and one outside the forest reserve. The one outside is operated by rod engines, being through comparatively easy country and having maximum grades of only 2.4% and a maximum curvature of 20°. On the Reserve division 60-ton Shay geared locomotives had to be used, the maximum gradient being 5% and the maximum curvature 60°.

The railroad is organized under the name of the San Joaquin & Eastern R.R. Co. as a common carrier under the supervision of the California railroad commission. It is reported that, in spite of the adverse topographical conditions, the road hopes to pick up a profitable business with the public. Until the power development is completed, the road will remain under the control of Stone & Webster Construction Co., which is doing the development work. The building of the railroad, including location, purchase of rights-of-way, arranging for government permits, and actual construction, was completed in 165 days, which is claimed to be a probable record for railroad construction through difficult country.

CAMPS—Little work was done before completion of the railroad, but since then two large permanent camps have been established, one at the basin and the other close to power house No. 1. These provide for approximately 1000 men each, although at present only 1500 men are employed. The construction company runs the boarding houses and maintains stores where clothing and necessities can be obtained. There is a hospital with a resident surgeon and nurse for the sick and injured. The main offices for the development of this project are in Fresno, but purchasing offices are maintained at San Francisco and Los Angeles.

TRANSMISSION LINE—The 6600 volts on the generators in both power stations will be stepped up to 150,000 volts for the transmission line. This will be 275 miles long and will comprise a double line of steel towers, each supporting three steel-cored aluminum-conductors arranged in a horizontal plane. By the use of an iron core and aluminum strands a large cable diameter results—a construction favorable to the reduction of corona losses which must be expected at this high voltage.

For a considerable part of the total distance, the lines will be built on private rights-of-way. The lines will deliver power to a Los Angeles sub-station, which will be equipped with synchronous condensers (super-excited synchronous motors) and step-down transformers.

U. S. FOREST RESERVE REGULATIONS—Since this project is in a forest reserve, it is interesting to briefly note the conditions under which the Department of Agriculture permits such development to be made.

Water-power permits are given, but these convey only the privilege of occupancy and use of land. No attempt is made to adjudicate water rights since these are acquired under state laws and adjudicated by the courts. Water-power permits ordinarily terminate at the expiration of 50 years, but the expiring permit is held to be an application for a new permit to occupy and use the land mentioned in the original.

"Preliminary" permits are made to allow the occupancy of the land within national forests for securing data required in making an application for final permit and for such construction as is necessary to preserve water appropriation during the early period. Only the final water-power permits allow the occupancy and use of land for construction, maintenance and operation of works, the main purpose of which is generation of electric power.

There is a class of development termed "non-commercial water-power" work, covering developments used solely for the operation of mines or in the milling and reduction of ores, as auxiliary to irrigation works, temporarily in the construction of other works for which privileges have been granted, or for municipalities and municipal purposes.

No charge is made for occupancy and use of land for non-commercial work. For commercial projects the permit is conditional on the payment of an annual charge based on the value of power purposes for such land, the measure of value for power being the "net power capacity" of the work. The rates of charge for each net electrical horsepower per year vary from 10c. to $1 for the first 10 years and remain constant at $1 for succeeding years.

The "net power capacity" on which charges are based is determined by the following deductions from "gross power capacity" of the entire works: (1) An amount bearing approximately the same ratio to the storage power of the reservoir or reservoirs as the area of unreserved and patented lands within the flood lines bears to the total area within flood lines; (2) an amount bearing the same ratio to the difference between gross power capacity and the storage power as the length of conduits on unreserved lands and patented lands bears to the total length of conduit; (3) a further deduction amounting to the square of distance of primary transmission multiplied by the factor 0.001, the deduction not to exceed 25%, however.

The "gross power capacity" from which deductions are made is interpreted to mean the power capacity of the entire works to be constructed, maintained, or operated under the permit—based on the estimated average annual station output in electrical horsepower under continuous operation with a reasonable load factor and with the use of all available water

falling to the maximum effective head, with proper deductions for reasonable mechanical and electrical losses in the generating machinery.

Preliminary permits are granted usually for a period not to exceed two years, though they are drawn up according to the circumstances of each particular case. When the time prescribed by state statutes, in which construction must begin in order to maintain water rights, is insufficient to prepare a final application before beginning construction, a clause is inserted in the preliminary permit allowing construction to proceed to an extent sufficient to permit compliance with state law. To prevent speculators holding the sites under preliminary permits, an annual charge is made during the term of the preliminary permit calculated on the basis of the estimated capacity of the proposed works and at the rates already noted. When the final application is filed in accordance with the terms of the preliminary permit, payments made under the preliminary permit are credited upon payments to become due under the final one.

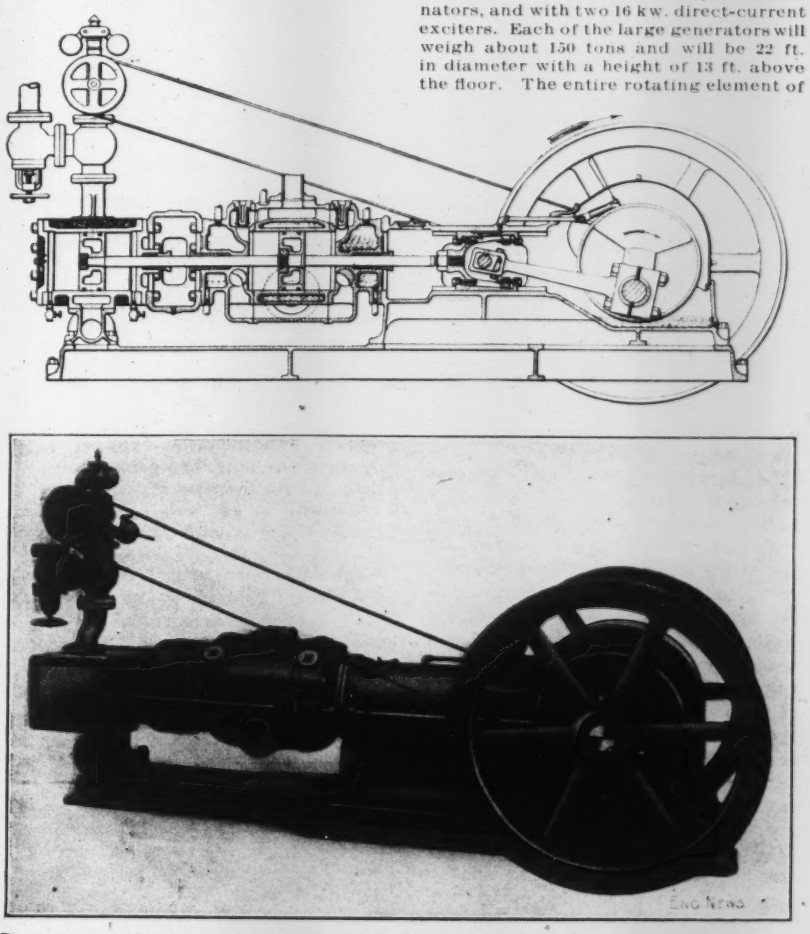
On the failure of a permitee to comply with the terms of a preliminary permit, the preliminary permit is terminated and no other application covering the same or adjacent lands is received from the same applicant for one year subsequent to the termination.

On receipt of an application which is in whole or in part included in an existing permit, the applicant is informed of the conflict and he is given an opportunity to amend his application to avoid the conflict, or he is enabled to renew his application at the termination of any existing permit which may be lost.

A New Design of Straight Line Air Compressor

We illustrate herewith a new air compressor with tandem steam and air cylinders which has recently been designed and put on the market by the Chicago Pneumatic Tool Co. While the machine in general conforms to usual practice in air-compressor design, it contains some special features. As seen by the drawings, the air cylinder is placed next to the guides and the steam cylinder in the rear. From a manufacturing point of view this has the advantage of making the same castings usable for either a steam-driven machine or belt-driven machine. The belt-driven machine is identical with the steam driven, except that the steam cylinder and the junction piece between the steam and air cylinders are removed, a shorter piston rod is used and a shorter sub-base. The pedestal on which the steam cylinder is supported is so designed that it can be set to face in four different directions for convenient connection to the exhaust pipe.

As seen in the perspective view, the yoke between the steam and air cylinders is made with a horizontal joint so that the heads of the air or steam cylinders next to this yoke can be removed without disturbing the cylinders themselves. The inlet valves of the air-compressor cylinder are of the Corliss rotary type, mechanically actuated, and lubricators are mounted on the bonnets of each of these air valves so that the lubricant reaches the valve directly and is carried into the cylinder with the inrushing air. This arrangement takes the place of the ordinary sight-feed lubricator. The air-compressor discharge valves are of the poppet type. The cylinder is water-jacketed on both heads and barrel. The cross-head is cylindrical and runs in bored guides. The cranks and eccentrics are inclosed by a planished-iron casing so that the main bearings, cross-heads, crank pins and eccentrics are all oiled by splash lubrication. A special oil catcher is provided at the top of the casing which receives the splashing oil and carries it through a pipe to the top cross-head guide and cross-head pins. The main bearings are babbit-lined and made up of removable cylindrical shells in three parts with adjustments for taking up wear.



PERSPECTIVE VIEW AND SECTIONAL ELEVATION OF "STRAIGHT LINE" AIR COMPRESSOR
(The Chicago Pneumatic Tool Co., Builders.)

The Largest Direct-current Generators yet designed are being built by the General Electric Co., of Schenectady, N. Y., for the plant of the Southern Aluminum Co. at Whitney, N. C. Here seven vertical waterwheel units (Morgan-Smith turbines) will each drive a 5,000-kw., 20,000-amp. 250-volt, 170-r.p.m. generator. There will be also two smaller direct-current generators rated at 2,500 kw. for 300 r.p.m., two 1250-kv.a. 514-r.p.m. alternators, and with two 16 kw. direct-current exciters. Each of the large generators will weigh about 150 tons and will be 22 ft. in diameter with a height of 13 ft. above the floor. The entire rotating element of the generators will be supported from an overhead bearing. The units are designed for safety at a runaway speed 75% above normal. Wheel governors will be provided with remote electric controls for hand and automatic operation.

The Southern Aluminum Co. was recently incorporated under the laws of New York with a capitalization of $8,000,000, being organized by aluminum manufacturers of Europe, notably L'Aluminium Francais of Paris. It is intended to have a large and completely equipped plant for the manufacture of aluminum. There will be nine furnace rooms, each measuring 60x500 ft. and there will be one electrode factory of similar dimensions. The work at Whitney is in charge of Dr. Paul Heroult, well known as a designer of electric furnaces.

Locomotives of the A., T. & S. F. Ry.

Increase in size and power of locomotives is a continuing and persistent feature of American railways, which is indicated in two ways: 1, in the recurrent appearance of the "heaviest locomotive in the world," and, 2, in slighter but steady advance in size of locomotives of the more ordinary character. This latter indication is noted in the article below, which describes a number of new engines for the Atchison, Topeka & Santa Fe Railway System. All of these engines are of types already in general use on the same road, but are somewhat larger, heavier and more powerful than preceding engines of these types. There are other points of interest besides size in the new engines, however; such as the extensive use of the balanced-compound in passenger service, the substitution of superheater simple engines for non-superheater compounds in heavy freight service, the improvement of frame bracing, the use of interchangeable designs for detail parts, and the application of power reversing gear. The article points out both the general and the special features of these new engines.

The tendency to introduce locomotives of increased size and power when purchasing new engines is evidenced in a large proportion of the new equipment purchased by leading railways, and the Atchison, Topeka & Santa Fé Ry. System has added to its motive-power equipment 70 new locomotives of different classes, which are somewhat more powerful than its former engines and which present some special features of interest. All of the engines were built by the Baldwin Locomotive Works. The engines include the following: 20 four-cylinder balanced-compound passenger engines of the 4:6:2 class, 20 freight engines of the 2:10:2 class; 10 freight engines of the 2:8:0 class, and 20 switching engines of the 0:6:0 class. All of these are oil-burning engines, with the exception of ten of the passenger engines and six of the switching engines.

The notable features in this lot of locomotives are as follows: 1, the continued extensive use of balanced-compounds in heavy passenger service; 2, the return to the 2:10:2 class of engine for heavy freight service, which class was introduced on this road in 1903; and, 3, the change from four-cylinder tandem-compounds to two-cylinder simple (superheater) engines in the 2:10:2 class. Some particulars of the principal features of the several designs are described below, and the principal dimensions of the road engines are given in the accompanying table. For information and drawings we are indebted to the railway company and the builders of the engines.

In general, the new locomotives are duplicates of others already in service on the road, and various detail parts are interchangeable with corresponding parts of the earlier locomotives. The differences between the former engines and the new ones are due to general development in locomotive design, and to changes made necessary by minor weaknesses or by local conditions. The boilers of all the new engines have radial-stay fireboxes, and all the locomotives for road service are equipped with Schmidt superheaters.

Balanced-compound Passenger Locomotives (4:6:2)

The A., T. & S. F. Ry. has used this type of engine extensively in heavy-duty passenger service for some years, and the new locomotives are generally similar to 28 balanced-compound engines of the same class furnished to this road last year by the same builders (Engineering News, Mar. 28, 1912). Their tractive force, working compound, is 34,000 lb. One of the new engines is shown in Fig. 1.

The inside (high-pressure) cylinders are placed on an angle of 7½°, with their centers 26¾ in. above the outside cylinder centers, measured on the vertical center line of the cylinder castings. The high-pressure piston rods are somewhat shorter than the low-pressure, in order to allow sufficient clearance between the main rods and the first driving axle. When the inside cranks are on the back dead center, the crossheads are immediately above this axle.

The inside guides are of the Laird type (with underhung crossheads), this design having been adopted because it provides a maximum amount of clearance under the crossheads. These guides are supported in front by the yoke which braces the outside guides, and are independent of the back cylinder heads. At the back they are bolted to a steel casting which extends the full depth of the pedestals of the leading driving axle. This casting has formed in it two openings, through which pass the high-pressure main rods. Immediately in the rear of this casting, the upper frame rails are braced by the valve-motion bearer. Another brace, a short distance ahead of the pedestals of the rear driving axle, is bolted to both the upper and lower rails of the frame. The transverse bracing of the frames in a four-cylinder balanced engine presents some difficult problems, but in these locomotives a very satisfactory arrangement has been obtained.

The design of the superheater calls for no special comment. The steam pipes pass out through the sides of the smoke-box and deliver steam directly to the steam chests.* The construction of the cylinder castings is thus materially simplified, the more so as the valves are arranged for inside admission to the high-pressure cylinders. The Walschaerts motion is used, and as the gears are driven from the outside (low-pressure) crankpins they are arranged in the same manner as when using outside-admission valves on a simple locomotive. The movement of the valve gears is controlled by the Ragonnett power mechanism.

The coal-burning locomotives are equipped with brick arches, and the grates and fire-door are operated by pneumatic power. The ash-pan has three hoppers, with swing bottoms which can be operated independently of each other.

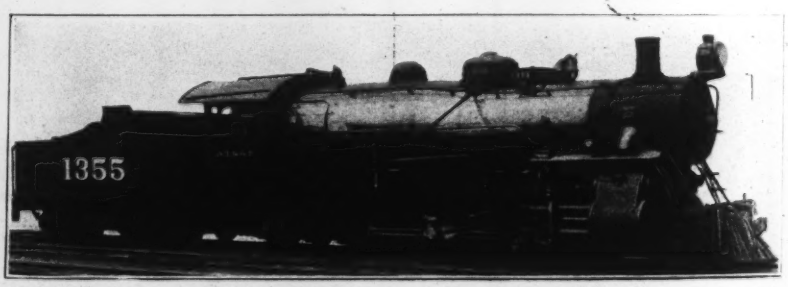


Fig. 1. Four-Cylinder Balanced-Compound Passenger Engine (4:6:2); A., T. & S. F. Ry.

Freight Engines (2:10:2)

The first locomotives with this wheel arrangement were placed in service by the A., T. & S. F. Ry. System in 1903, and during 1903-1907 a total of 160 locomotives of this type were built by the Baldwin Locomotive Works for service on the mountain divisions. Some of

*This arrangement of steam pipes in other engines was described and illustrated in our issue of July 18, 1912.

these engines have undergone extensive alterations by the railway company, and several have been converted into Mallet compounds by the addition of forward steam-truck units. In the new locomotives the most notable change lies in their

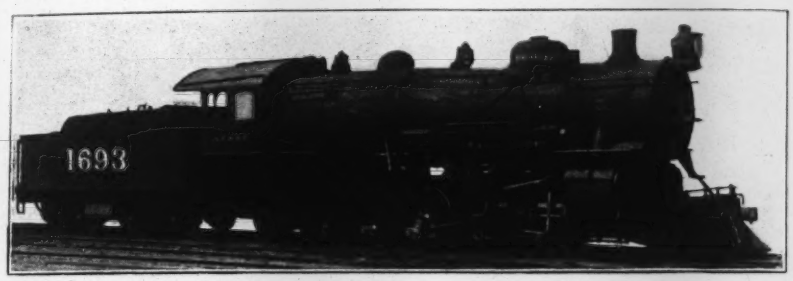


FIG. 2. HEAVY FREIGHT LOCOMOTIVE (2:10:2); A., T. & S. F. RY.

being simple engines using superheated steam, instead of tandem-compound engines using saturated steam. There is also a slight increase in weight, due chiefly to the use of a larger boiler. The shell diameter at the front end has been increased from 78¾ in. to 80¾ in., and the tubes have been lengthened from 20 ft. to 21 ft. The firebox dimensions, however, are practically unchanged. Fig. 2 shows one of these engines.

The Schmidt superheater has 36 elements, which are placed in as many 5½-in. tubes. The superheated steam is delivered direct to the steam chests through outside pipes. Inside-admission piston valves, 16 in. diameter, control the steam distribution. These valves are driven by Walschaerts gear and are set with a lead of ¼ in. The Ragonnet power-reversing mechanism has been applied as a result of continued trial on previous engines of other classes. The main cylinders are oiled by a five-feed lubricator, which has a lead to each steam pipe and one to each cylinder barrel.

The frames are of cast steel, with main sections 5 in. wide, cast in one piece with single front rails. Transverse braces of cast steel are placed midway between the adjacent pairs of driving pedestals, except that at the rear the brace is placed close to the fifth driving axle and forms a seat for the sliding shoes which support the front end of the firebox. The back end of the firebox is supported on an expansion plate bolted to the footplate. Just back of the fifth pair of pedestals, the rear frames are spliced to the main frames. The rear truck is of the Rushton type with inside journals.

Provision has been made for ample bracing of the frames at the front end. Just forward of the cylinders they are secured to a cast-steel deck-plate; while between the cylinders and the leading driving pedestals is a substantial transverse brace of cast steel, which also supports the driving-brake shaft. The brake cylinders are bolted to the guide yoke. Each guide bearer is braced by a longitudinal cast-steel tie, which is bolted at its forward end to the top of the steam chest. To compensate for deficiency of counterbalance weight in the wheel centers, counterweights are keyed to the main driving axle (between the frames), as in the larger locomotives of the same class built recently for the Chicago, Burlington & Quincy R.R. (ENGINEERING NEWS, Sept. 19, 1912).

The equipment of these locomotives includes cylinder relief valves, and Sheedy drifting valves. Flange lubricators are applied to the leading pair of driving wheels. The oil-burning equipment is in accordance with the railway company's practice, with a 2-in. Booth burner placed in the forward end of the firebox.

FREIGHT LOCOMOTIVES (2:8:0)

These engines, shown in Fig. 3, exert a tractive force of 48,800 lb., and carry an average weight of nearly 49,000 lb. on each pair of driving wheels. The general design is based on that of engines which were placed in service by this railway in 1908. The weight has been somewhat increased, due to enlarging the boiler to accommodate the superheater. The boiler is of the wagon-top type, with wide firebox, and the front portion of the mud-ring is sloped to secure sufficient depth of the throat. These engines are all oil-burners, but the staybolts are so spaced that a brick arch with water tubes can be applied, if at any time it is desired to change to coal fuel.

As in the other road engines, the superheater is arranged with outside steam pipes, and the valves are driven by the Walschaerts valve gear. The link and reverse shaft bearings are bolted to the guide bearer. The combining levers are pinned directly to the valve stems. A longitudinal bearer is placed on each side of the locomotive, and is supported in front on the cylinder casting and at the back on the guide yoke. To this bearer is bolted a bracket which supports the valve rod. This arrangement provides an efficient brace for the guide yoke, besides providing a valve-rod support which is independent of the main guides. The frames are 4½ in. wide, with double front rails. They are connected by two transverse braces extending the full depth of the pedestals; these are placed midway between the second and third, and third and fourth axles, respectively. The firebox is supported by sliding shoes in front and an expansion plate at the back.

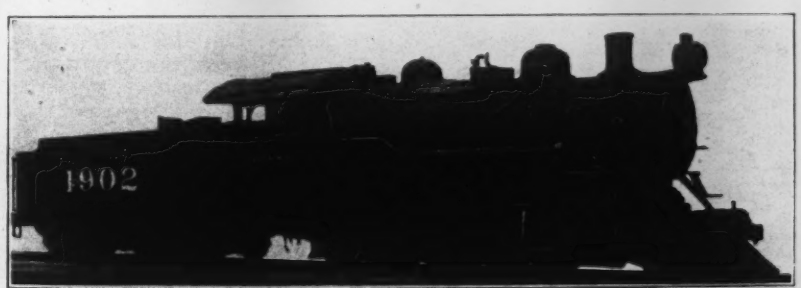


FIG. 3. FREIGHT LOCOMOTIVE (2:8:0); A., T. & S. F. RY.

SWITCHING LOCOMOTIVES (0:6:0)

These engines are all equipped with the Stephenson link motion and the steam distribution is controlled by 12-in. piston valves. They have wagon-top boilers with long fireboxes placed above the frames. The cylinders are 20x26 in., and with 51-in. wheels and a steam pressure of 180 lb., the tractive force is 31,200 lb. The total weight, equipped for coal burning, is 77 tons. The design is one which this road has used in general switching service with very satisfactory results.

POWER-REVERSING GEAR

The power-reversing mechanism used on the passenger engines and the 2:10:2 freight engines is of the type invented by E. L. Ragonnet. It was designed particularly with a view to facilitate the handling of Mallet duplex locomotives, since when reversing the engine or changing the point of cut-off it is necessary to operate both sets of valve-gears simultaneously. This requires so much power that with hand-operated reversing mechanism the enginemen would not be likely to shift the cut-off more often than is absolutely necessary, with the result that the engine would not be worked in the most economical manner. This power gear has been applied also to large engines of ordinary classes. It is operated

preferably by compressed air, although in several cases steam is used.*

The construction of this reversing gear is shown in Fig. 4. In brief it consists of a horizontal cylinder *A*, whose piston rod *B* actuates a sliding crosshead *C*, which is connected to the reach-rod by an extension lever *D*. The movements of the piston are controlled by a small lever and sector in the cab. The distribution of air (or steam) to the reversing cylinder is controlled by a plain slide-valve *E*, arranged for outside admission. The crosshead gibs *F* are held in place by a plate or arm *G*, which carries a projecting stud *H*. This stud engages a slot in the floating lever *J*, the upper end of which is connected to the reversing lever in the cab by means of a link, rocker and pipe rod (*KLM*). The floating lever is connected also to the stem of the slide-valve by a rod *N* (near the top of the lever). The rocker *L* is provided with safety arms *OO*, which strike the adjustable stops or setscrews *P*, when the reversing lever reaches the limit of its movement on either side of its central position.

The reversing lever is locked at any desired position by a spring latch working in the toothed sector. When this lever is in its central position, the slide-valve covers both admission ports. When the lever is moved into forward gear (Fig. 4), the floating lever *J* swings on the stud *H* so that the slide-valve is moved forward and uncovers the rear port *Q*. Air is thus admitted to the front of the cylinder (the ports being crossed), and the piston moves to the rear. As it moves, the floating lever *J* swings on its upper end, and thus shifts the valve back (or to the left). When the link blocks have been shifted to position for the desired cut-off, as indicated by the position of the reversing lever, the slide-valve again closes the rear admission port (and both ports) and the movement of the piston ceases.

For backward gear, the movements are in the opposite direction, and the forward admission port *R* is opened to the rear end of the cylinder. It will be seen that when the gear is set for any particular point of cutoff the slide-valve is in its middle position. The exhaust or inside lap of the valve is materially greater than the outside lap (usually ⅛ in. for the former and 3/32 in. for the latter), so that air can be held on both sides of the piston simultaneously, thus locking the mechanism. The cylinder is oiled from a small lubricator in the cab.

The arrangement shown in the drawing is varied in some cases to suit particular arrangements of the valve gear. Thus the cylinder may be placed on the opposite side of the floating lever, and in such position that the bottom of this lever engages a stud on the crosshead, instead of on an extension arm as in the arrangement illustrated.

*A screw reversing gear for the same purpose was described and illustrated in our issue of July 18, 1912.

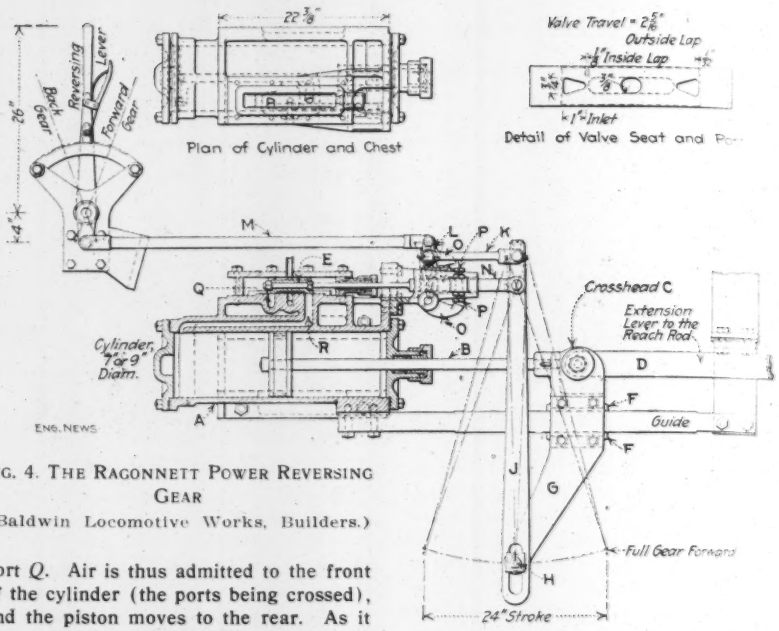


FIG. 4. THE RAGONNETT POWER REVERSING GEAR
(Baldwin Locomotive Works, Builders.)

DIMENSIONS OF NEW LOCOMOTIVES; ATCHISON, TOPEKA & SANTA FE RY. SYSTEM.

Class of engine	4:6:2	2:10:2	2:8:0
Service	Passenger	Freight	Freight
Simple or compound	4-cyl. comp.	Simple	Simple
Driving wheels; No	6	10	8
Driving wheels; diam	6 ft. 1 in.	4 ft. 9 in.	4 ft. 9 in.
Front truck wheels, diam	2 ft. 10½ in.	2 ft. 5½ in.	2 ft. 5½ in.
Rear truck wheels, diam	4 ft. 2 in.	3 ft. 4 in.	.....
Tender wheels, diam	2 ft. 10½ in.	2 ft. 10½ in.	2 ft. 10½ in.
Journals, main driving axles	11x10 in.	11x12 in.	10x12 in.
Journals, other driving axles	9x12 in.	10x12 in.	9x12 in.
Wheelbase; Driving	13 ft. 8 in.	19 ft. 9 in.	15 ft. 6 in.
Total engine	35 ft. 1 in.	35 ft. 10 in.	24 ft. 6 in.
Engine and tender	67 ft. 0 in.	66 ft. 4 in.	58 ft. 3in.
Weight in working order:			
On drivers	163,500 lb.	248,900 lb.	195,500 lb.
On front truck	54,600 lb.	21,400 lb.	30,800 lb.
On rear truck	50,700 lb.	25,600 lb.	.....
Engine, total	268,800 lb.	295,900 lb.	226,300 lb.
Engine and tender	440,000 lb.	470,000 lb.	385,000 lb.
Cylinders; high pressure	(2) 17½x28 in.	(2) 28x32 in.	(2) 23½x32 in.
Cylinders; low pressure	(2) 29x28 in.	.....	.....
Valve gear	Walschaerts	Walschaerts	Walschaerts
Valves	Piston	Piston	Piston
Boiler; type	Wagon-top	Wagon-top	Wagon-top
Diameter	6 ft. 10 in.	6 ft. 10¾ in.	6 ft. 6¾ in.
Plates, thickness	11/32, 13/32, & ½ in.	11/32, 13/32, & ½ in.	¼, 13/32, & 11/32 in.
Working steam pressure	210 lb.	170 lb.	185 lb.
Firebox; type	Radial	Radial	Radial
Length inside	9 ft. 1⅛ in.	9 ft. 0 in.	7 ft. 11½ in.
Width inside	6 ft. 4½ in.	6 ft. 6 in.	5 ft. 1½ in.
Depth at front	6 ft. 3½ in.	6 ft. 8½ in.	6 ft. 6¼ in.
Depth at rear	5 ft. 5½ in.	6 ft. 5½ in.	5 ft. 8 in.
Plates; side, back and crown	½ in.	½ in.	½ in.
Tube plate	5/8 in.	5/8 in.	½ in.
Water spaces, width	4½ & 5 in.	6 in.	4 & 4½ in.
Tubes; material	Iron	Iron	Iron
Number	199 & 26	251 & 36	256 & 34
Diameter	2¼ & 5½ in.	2¼ & 5½ in.	2 & 5½ in.
Length over tube plates	21 ft. 9 in.	21 ft. 0 in.	14 ft. 9 in.
Heating surface; tubes	3,233 sq.ft.	4,174 sq.ft.	2,658 sq.ft.
Firebox	181 sq.ft.	193 sq.ft.	200 sq.ft.
Arch tubes	29 sq.ft.	.....	.....
Total	3,443 sq.ft.	4,367 sq.ft.	2,858 sq.ft.
Superheating surface	619 sq.ft.	910 sq.ft.	565 sq.ft.
Grate area	57.56 sq.ft.	58.5 sq.ft.	47.2 sq.ft.
Water in tender tank	9,000 gal.	9,000 gal.	8,500 gal.
Fuel in tender	12 tons coal, or 3,300 gal. oil	3,300 gal. oil	3,300 gal. oil

The Arrowrock Dam, the highest dam in the world, now under construction by the U. S. Reclamation service, has reached bed rock on the work of excavating for its foundations, at a depth of 90 ft. below the river surface. The dam, which is located on the Boise River in southern Idaho, will be 251 ft. high, 1,060 ft. long on top, and 270 ft. thick at the bottom. Its foundations will cover an acre.

In order to take care of the river during construction a tunnel was driven through the lava bench at the south end of the dam site. It is 500 ft. long, 35 ft. wide, and 25 ft. high, the arched top having a 10 ft. rise. It is big enough to carry the river even at flood in ordinary years, and for five years the river will flow through this channel, until the dam is completed.

Power for construction purposes is furnished by the Government power house at the Boise diversion dam, 12 miles above Boise, where 2,000 hp. is developed and energy transmitted electrically to the dam site.

When completed the Boise irrigation system will furnish water to approximately 250,000 acres.

Shelters and Waiting-Rooms for Electric Railways*

Waiting rooms and shelters are becoming very pertinent problems in connection with the electric railway. The public and the authorities are continually urging the companies for more facilities, and where comparatively few waiting rooms were required outside of permanent stops and stations on the interurban lines a few years ago, it is not uncommon to have requests for shelters on the urban property at junctions of lines or at the terminus of a route. It is true that requests for facilities of the above nature are often not worthy of consideration, but there may be good reasons for the waiting room. Again, in some instances it is necessary to have protection and conveniences for the company's employees at the end of a long line at a considerable distance from the car house, which may be advantageously combined with a shelter for the public.

Generally we may divide waiting rooms or shelters in the following classes: 1, Open, or semi-closed shelter.

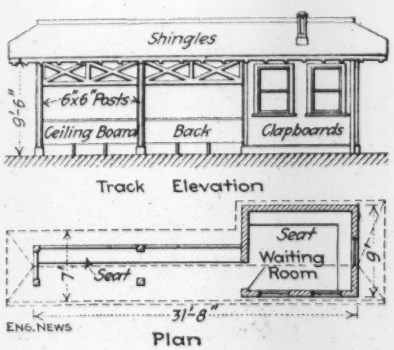


FIG. 1. COMBINATION OPEN AND CLOSED WAITING ROOM FOR ELECTRIC RAILWAYS

2, Closed shelter or combination of the open and closed shelter. 3, Closed shelter without heat, but equipped with non-freezing toilets. 4, Closed shelter with toilets and heat. 5, Waiting room in connection with news-stand or store. 6, Waiting room at the station or terminal.

In the first class we have a very large variety, varying from the most modest sort of a shed to the more substantial station with steel frame and tile roof, or constructed of concrete with permanent floors.† It is often more economical for a company to build these small sheds at its own shops and ship to the site on a work car. The foundation may be of timber or concrete and floors ordinarily laid with screenings or ashes.

*From the report of the Committee on Buildings and Structures, presented at the annual meeting of the American Electric Railway Engineering Association, held at Chicago, Oct. 7 to 11.

†The report showed some examples of such shelters which were illustrated in our issue of June 1, 1911.

The semi-closed type of shed where there is not supervision, is popular, because you have two conditions to meet: 1, there should be enough inclosure to afford protection against the rain, and 2, it is not desirable to afford hiding place for vagrants.

The location of the waiting room may be such that it is under constant surveil-

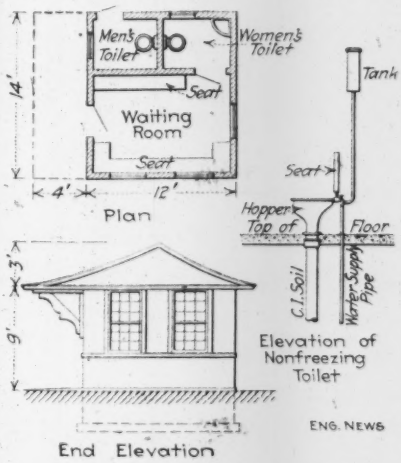


FIG. 2. CLOSED WAITING ROOM WITH NON FREEZING TOILET

lance, and Fig. 1 is an example of a combination of the open and closed waiting room of Class 2. Ordinarily, the open-shed portion is used, while during very inclement weather a protection is afforded by the closed portion of the building. The waiting room may be inclosed with glass, but ordinarily there is much objection to this on account of the care and cost of maintenance.

When toilet facilities are required the waiting room begins to be a more serious consideration. Generally, these conveniences carry with them heating, lighting, supervision and higher cost of maintenance. A very economical arrangement is shown in Fig. 2. This waiting room is supplied with the non-freezing toilet. This arrangement does not require any heating or constant supervision and is often desirable at such locations as at the end of a trolley line, where it may be used by both the employees and patrons. The non-freezing toilet is an arrangement so that no water remains in exposed piping. The device is automatic so that raising the seat fills with water a flush tank overhead, and lowering seat releases the valve that permits the flushing of the bowl.

Sometimes isolated waiting rooms are required that must be fitted up with toilets, heating and lighting, but this is rare. If toilet facilities are required it is generally best and cheapest to make the waiting room large enough to secure a store space that may be a source of revenue, or at least furnish funds to meet the supervision and upkeep of the waiting room. This scheme is proving very satisfactory and recently is being advocated by many railway interests.

Fig. 3 shows the layout of a waiting room 12x24 ft., with two toilets and a store space 16x24 ft. The cost of the complete building was $1500, and the store is rented by a vendor, who sells fruit, candies and newspapers, at a nominal amount per year. In addition, the vendor looks after the waiting room, keeps it heated and in good operating and sanitary condition. Some such arrangement as just described, where it is necessary to provide facilities at an isolated waiting room, is certainly the most desirable plan that has yet been introduced to any great extent. The recommendations and conclusions of the committee are as follows:

1. Where only waiting places for patrons are required, as is the case at the interurban stop, the semi-closed shelter is recommended.

2. If it is necessary to maintain toilets and it is not practical to combine a news-

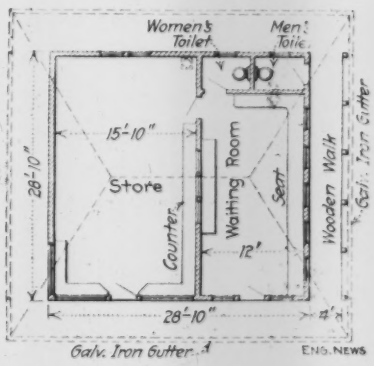


FIG. 3. COMBINATION WAITING ROOM AND STORE FOR ELECTRIC RAILWAYS

stand or store in connection with the shelter, non-freezing toilets are satisfactory.

3. Where isolated waiting shelters are required and it is necessary to provide toilet facilities, a shelter should be provided that includes a news-stand or store. The proprietor of the store may be engaged to look after the waiting room and appurtenances in return for privileges.

International Exposition of Inventions—A second international exhibit of inventions and patented devices will be held in St. Louis, Mo., Nov. 11-17; the first such exposition was held in the same city in September, 1911. The object of the exhibit is to place before the public, capitalists and prospective manufacturers, the products of the inventive genius of many workers. At the first exposition, which was largely experimental, many inventors were able to dispose of their patents outright and many succeeded in interesting capitalists sufficiently to have their inventions developed.

A Street-Paving Machine

By Carroll Ashley*

The writer believes that a machine just completed in Los Angeles for the complete mechanical paving of streets and roads is a notable achievement worthy of description. It is intended to do only one kind of work—a form of "petrolithic" paving which involves the mixing of asphaltic-oil, or some other suitable binder, and steam with stone, sand and dirt and rolling the mixture back into place on the road. Before this machine begins operation, the roadway must be properly shaped and graded; after that the surface is excavated by the machine to any desired depth between limits of less than 1 in. and 12 in. The mixture of earth, sand and stone is elevated to a screen box which sorts out the coarser material and dumps it back on the subgrade, leaving the finer mixture to go through the atomizing coater and then to be thrown on the road for rolling down.

The machine shown in the accompanying figure is the only one yet built, though a larger one, to pave a strip 3 ft. wider, is contemplated. This machine is reported to have cost $22,000 in development. The design is the joint work of Edward Double, president and general manager of the Union Tool Co., of Los Angeles; William N. Murray, a local builder of road machinery, and E. W. Goeser and T. A. Pheton, mechanical engineers of the Union Tool Co. Patents have been secured in this and foreign countries and the designers are very optimistic as to the future of the machine.

The one machine now built weighs 25 tons and is propelled and operated by a 25-hp. gasoline engine. It travels at 7 ft. per minute (about 0.08 mile per hour) when working and lays a strip 5 ft. wide. On its reverse drive it can travel at about five miles per hour.

*625 Esperanza St., Los Angeles, Calif.

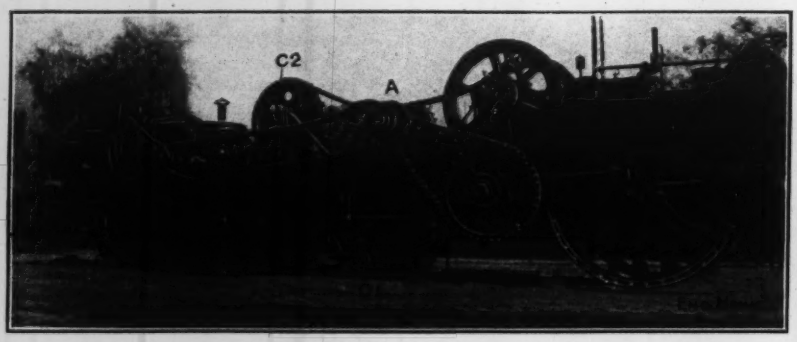


Fig. 1. A Street-Paving Machine
(Built by the Union Tool Co., of Los Angeles, Calif.)

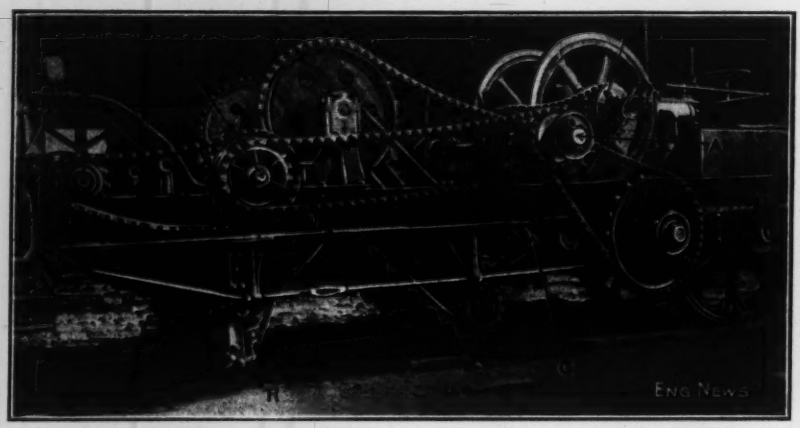


Fig. 3. Drive Chains of Los Angeles Street-Paving Machine

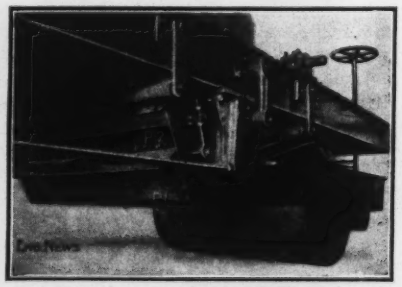


Fig. 5. Separator Screen Boxes of Los Angeles Street-Paving Machine

Large traction wheels (Fig. 1) are the front. Above and just back of th is the engine, chain connected to main countershaft. Still further back the elevating excavator; this has sm steel buckets alternately with plain a toothed edges. Each string of buckets on a separate chain running over sproc ets, loose on the lower shaft but key on the upper one. Between the two

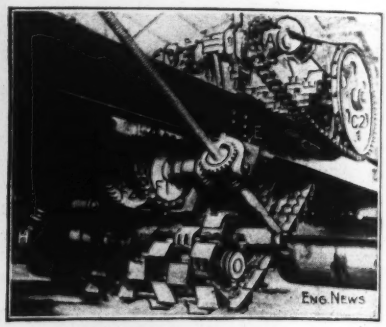


Fig. 2. Excavator Lift Gearing

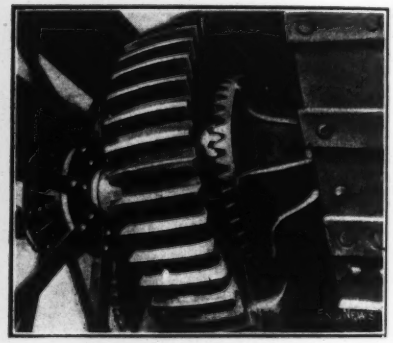


Fig. 4. Differential Gear of Traction Drive

shafts are three adjusting screws for taking up excess play. The upper shaft is driven by chains from the main countershaft.

At *E* (Fig. 2) is a cross-shaft with bevel gears connecting with gears on right- and left-hand screw shafts on each side of the machine respectively, for raising or lowering the excavator. This is done by power and a reversing drive is secured by a fricton clutch engaging with either of the two idle wheels *F*1 and *F*2 driven in opposite directions. Back of the shaft *E* is another (the journal of which is seen at *G*, Fig. 3), on which are keyed a pinion and a sprocket; the pinion meshes with the gear *F*2, while this sprocket and the sprocket *F*1 are both driven by one chain passing over them and over the main drive-shaft.

At the left of Fig. 2 is the end of a worm gear meshing with a large wheel; the latter is part of a gear train leading to the front-wheel axle. The crank and handle at the right of the worm (Fig. 2)

holds the latter into mesh. The worm shaft is driven by bevel gears on the main drive-shaft, as may be seen from Fig. 3. The higher-speed drive for this train of gears is through the sprocket *J*.

The bull wheel seen in Fig. 4 is part of the last member of the traction gear train mentioned. This wheel runs idle on the axle and carries three small bevel pinions inside its periphery, meshing with two bevel gears *K* on either side of the bull wheel and forming a differential drive. One traction wheel and bevel gear are fastened to the wheel axle. The other

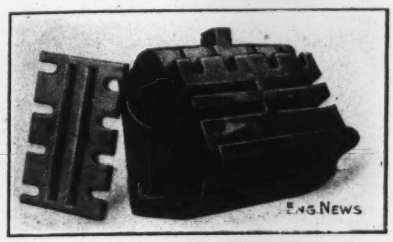


FIG. 6. ATOMIZER CASTING

wheel and gear are mounted on a sleeve loose on the same axle. The bearings of this axle are castings which can be moved on circular gibs fastened to the frame, leading to a horizontal handwheel for steering. A similar arrangement is used for the rear roller, both ends of the machine being worked for steering. In Fig. 3 the sprocket *O*1 and its mate on the other side of the machine are on the

FIG. 7. ASSEMBLED ATOMIZER CASTINGS AND SAND PUMP ROTOR; LOS ANGELES PAVING MACHINE

upper excavator shaft; *O*2 drives the separator screen and *O*3 the oil pump. A tank wagon is used with the machine and the oil is pumped directly into the atomizer for coating the road material. Fig. 6 shows the screen boxes into which the separator discharges the material received from the excavator. P.1 is the small opening for sand and earth and P.2 that for stone.

The heart of the machine is really the oil atomizer, shown at *R*, in Fig. 3, under the screen bars *P* (but removed in Fig. 6). Fig. 8 shows one of the atomizer section castings, together with a grooved brass plate to cover the ports, one of which is for steam and the other for oil. Each casting has tapped holes in the rear for piping. The brass plate has small holes so spaced that the steam and oil play simultaneously on the dirt and small stone. The assembled castings are seen in Fig. 7 and also the rotor of a sand pump which is suspended in front of and a little above the atomizer. The fine material dropping from the screen box is caught in the sand pump, running at 1200 r.p.m., and thrown down through the steam and oil with almost enough force so that rolling is not needed to compact the pavement. Steam is generated at 600 lb. pressure in a Stanley boiler, mounted on a rear end.

All the parts of the machine are driven through clutches so that any function is cut out at will.

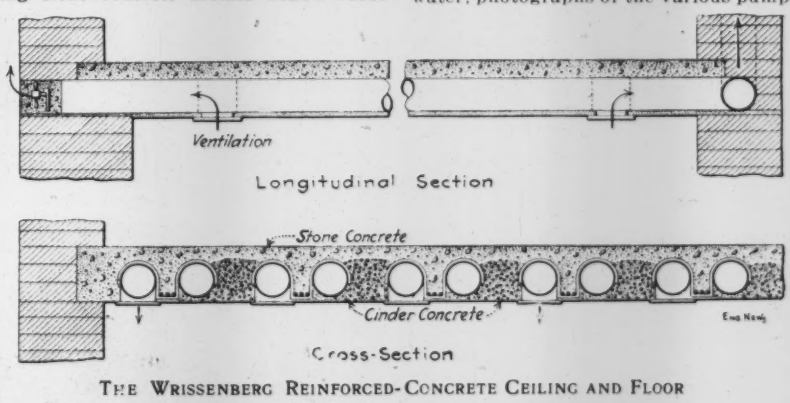
Testing out of the machine has shown but few weak points. A few changes have been made in the atomizer and the driving wheels are to be wider. Some simplification is to be made. A strip of pavement has been laid 800 ft. long, single width.

A New German Ceiling and Floor

The Wrissenberg reinforced-concrete floor and ceiling construction shown in the accompanying cut is a German patent which has been widely used in Germany, mainly in public buildings and hospitals. Its main features are its lightness, cheapness and the facilities it affords for effective ventilation of the room it covers.

It consists of a series of adjoining reinforced-concrete beams formed by placing stone concrete around hollow tubes which stretch between the walls supporting the floor, and filling in the intermediate spaces with cinder concrete. In construction a falsework is first erected and upon it is laid a thin layer of stone concrete. On this layer are placed, with uniform spacing, as shown in the figure, a number of cardboard tubes or stove pipe, fitting into each other longitudinally to make the proper length. Around these tubes are set the so called spectacle frames to hold them in place and also to hold the longitudinal rods which reinforce the beams. The space between the separated tubes is then filled with cinder concrete and the remaining space finally brought to a floor level with stone concrete. The construction thus forms a series of connected T-beams, which can be figured as such.

The ventilating possibilities of the pipe floor may also be noted from the figure. The tubes may be opened at any point in the ceiling and a free connection thus established between any required riser pipes or the outside air and the room covered by the floor.



THE WRISSENBERG REINFORCED-CONCRETE CEILING AND FLOOR

The Municipal Water Conservation Exhibit at Philadelphia, Penn., noted in our issue of Sept. 12, was continued from Oct. 5 to Nov. 7 instead of for the first two weeks only as originally planned. Regarding this exhibit the Philadelphia "Public Ledger" of Oct. 27 says:

It has attracted such widespread attention, not only in Philadelphia but generally throughout the country, that the committee having charge of the exhibit estimates that more than 600,000 people availed themselves of the opportunity of observing the latest improved devices to prevent the wanton waste of water. Letters of inquiry and commendation have been received by the city from Public Works Departments in St. Louis, Indianapolis, Boston, Chicago, New York and many large Western cities. That the plan of educating the public to the conservation of its water supply, which originated in Philadelphia, will be rapidly followed by the authorities of other cities, is evidenced by the widespread interest of engineers and public works officials.

As a direct result of the exhibition, there have been voluntarily installed in the city more than 2500 water meters.

The committee and a large number of city officials have been in personal attendance upon the exhibition, and have done everything possible to make it a success.

The main pavilion of the exhibit contains charts which give interesting statistics in connection with the use of water; photographs of the various pumping and filtration stations of the city. In the exhibit are also shown samples of water in all different stages of purity from the raw water, characterized as "fit only for painting purposes," to the practically pure filtered article. Comparative costs with meter rates are shown by a display of tank filtered water at a cost of one cent for 2000 pints. A graphic comparison of water supplies in other cities is made by means of wooden tanks illustrating the consumption per capita. In this exhibit are also shown specimens of old types of wooden pipes laid in 1799, and removed from the ground in good state of preservation but a few years ago. In comparison are shown samples of the present-day cast-iron pipe. At the evening session the department exhibits, by means of lantern slides, the various statistics, views of leaky hydrants, faucets and other means of water wastage. There are 125 views in the course of an evening.

The Riverside Dam, Indianapolis, Ind.; Its Successive Failures and Repairs

By Charles Brossmann*

A recent failure of one of the wing walls of the Riverside Dam, in Indianapolis, Ind., has brought into local notice a structure which has suffered more than ordinary vicissitudes in the 13 years of its existence. For the purposes of record there is given below a description of the various failures and repairs to the bridge and of its original and subsequent design.

This dam, which was built in 1899 by the Indianapolis Park Board, across the White River, some 1000 ft. below the Emrichsville Bridge, backs up the water of that river for several miles through public park property. It is built of concrete, with Bedford stone facings, and is of gravity section, with an arched outline in plan, although the low rise of the arch and the condition of the abutments makes it doubtful if the arch at all aids the stability. At each end of the dam is a circular stone parapet and a stone wing wall extending some 30 ft. on each side of the dam. At present there is also an extension wing wall of concrete, reaching 150 ft. downstream on each side. This was built after the original construction, as noted below. (Fig. 3.)

The dam was originally built, as shown in the upper section, Fig. 1, of concrete with a stone facing and a stone apron resting on a concrete slab supported by the main section and a downstream concrete wall. The area between the wall and the section was of earth, that is, the cut-off forward wall, was sunk in the river bottom. About 1906 a considerable length of the dam was undermined in the downstream end, the stone apron and the wall supporting it being undermined and sinking into the river bed at various points. This was repaired by driving piling about 20 ft. long into the hardpan and dumping in concrete to form the section shown at the left in Fig. 1, making a mass about 18 ft. from the dam proper and about 14 ft. deep. Evidently this repair was far from being well done, as it was only a short time until this was washed away, and the dam was again in danger.

In 1908 repairs on the main structure were again made, as it was found that the river bottom had washed out from the heel of the dam down under the dam and washed out a hole about 8 ft. deep, and almost 45 ft. in length (not shown on the sections) near the center and slightly to the north. Furthermore, part of the old apron which had not formerly needed repair was now found in defective condition. Fig. 2 shows portions of the stone apron and the wall supporting it,

*Consulting Engineer, Union Trust Bldg., Indianapolis, Ind.

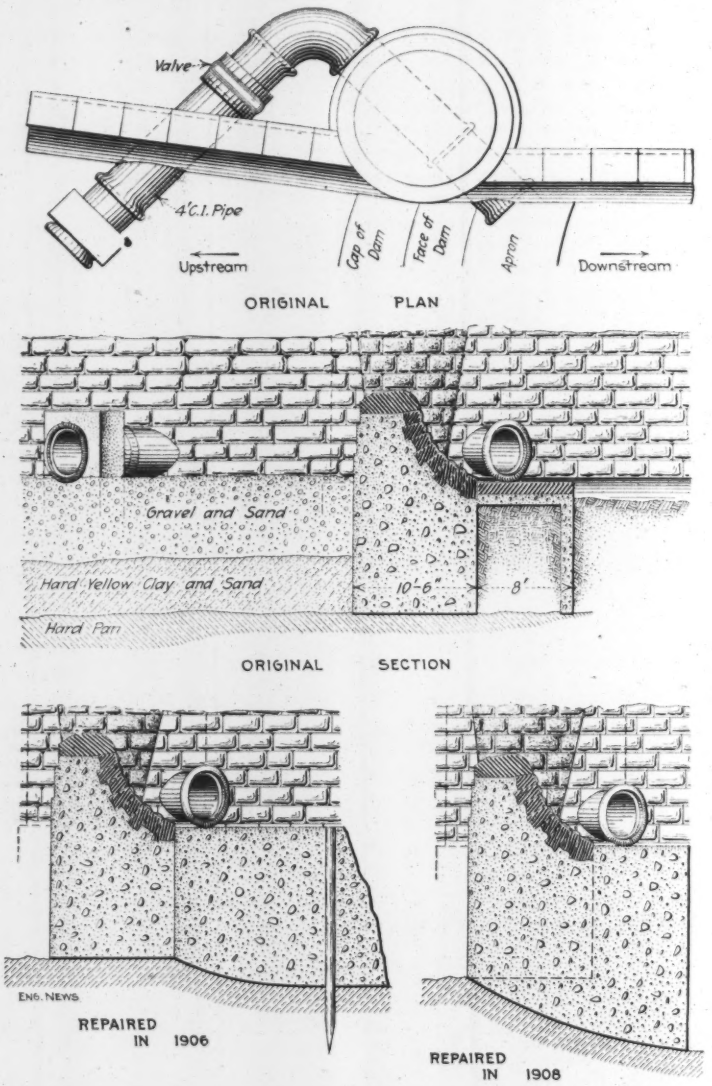


Fig. 1. Sections through Riverside Dam Showing Successive Repairs

Fig. 2. View Under Toe of Dam Showing Washed Out Apron Stones

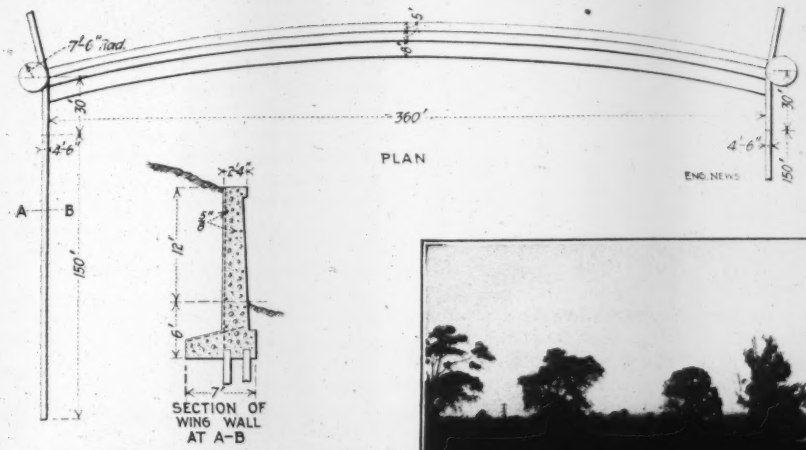


FIG. 3. PLAN AND SECTION THROUGH CONCRETE WING WALL, RIVERSIDE DAM, INDIANAPOLIS, IND.

looking upstream toward the dam proper. This new break was repaired, as shown at the right, Fig. 1, by building a coffer-dam on both sides of the structure, using 2-in. sheet-piling with clay puddle filling between the two rows of piling. The entire opening was then filled with concrete.

Fig. 4 shows the coffer-dam and work of repair under construction, looking north across the dam. The photograph was taken in August, 1908. Other views taken at that time, but not reproduced here, show that the piling from the old repair in 1906 gave evidence of being well scoured by the current, and the concrete of not being very permanent.

There has evidently been no further trouble to the dam proper since this repair, but a short time ago a break in the wing walls took place and their present condition is shown in Fig. 5. The old abutment of stone was built at the same time as the dam in 1899, and extended down stream about 30 ft. In 1904 a wall 150 ft. long was added, the section of this wall being shown in Fig. 3. This wall was designed with reinforcing, but the break shown in Fig. 5 does not reveal any reinforcing material, although the writer is advised that the wall was built with such rods. The eastern end of the abutment has broken away and a large crevasse is now there and the wall leans toward the river. There is also evidence of the need of attention to the stonework, for water has started to seep through. While this at present does not effect the stability of the dam in any way, it should be repaired to save future trouble.

The sluiceway coming through the parapet is a 4-ft. cast-iron pipe, and it is quite probable that this was the main cause of the failure of the side walls, as, no doubt, considerable scouring and washing out from under the wall has been caused by this current of water forming eddies under the wall, thus resulting in failure.

The latest break as yet has not effected the impounded water above the dam, but unless repaired it must wash out more and more and finally undermine the dam itself at this point, for if this parapet is demolished neither the arch action of the dam or its gravity section can keep off this undermining and consequent failure.

FIG. 4. VIEW OF THE RIVERSIDE DAM LOOKING NORTH IN 1908
(Showing coffer-dams upstream and downstream)

FIG. 5. BREAK IN WING WALL, 1912, RIVERSIDE DAM, INDIANAPOLIS

The Park Board has notified the City Council of the condition of the dam and of the fact that it has no money to make the proper repairs, as the dam itself is not in the park but in the city. At the present time there is no public fund with which to repair the break, and neither the Park Board nor the Board of Public Works will assume the responsibility. It is stated that estimates as high as $10,000 are given to make repairs.

Just what would be the effect of this dam going out in high water it is impossible to say. The pumping station and reservoir of the Indianapolis Water Co. is just below this point, but they are on higher ground and protected by levees, although about ten years ago at high water considerable damage was caused to the property simply by high water in the river.

The Construction of the South Main Pier of the Quebec Bridge

Owing to the fact that the new Quebec Bridge is some 21 ft. wider and nearly twice as heavy as the old bridge, it was necessary to construct entirely new piers for the new structure. This work has been going on for the past two years, and will probably require another year to finish.

The bridge has three approach spans, two on the north side and one on the south, having a total length of 409 ft.; two anchor spans of 515 ft. each; two cantilever spans 580 ft. each; and one suspended span 640 ft. in length. Thus its total length is 3239 ft., face to face of abutments. The channel span is 1800 ft., c. to c. main piers, being the same as that of the old bridge (but shifted 65 ft. southward).

Last season the caissons for the north main pier were successfully sunk to solid bottom some 80 ft. below high water, or 50 ft. below the bed of the river. This season the contractor has concentrated his efforts upon the sinking of the mammoth caisson for the south main pier. The foundation for the north pier comprised two caissons, each 60x85 ft., set 10 ft. apart, this space being filled with concrete after the sinking was effected. On the south side one single caisson is being employed, 180x55 ft. The caisson is being carried down to solid rock 85 ft. below the level of the river bed and 100 ft. below extreme high water.

Preparation for Sinking

The caisson was floated into position last season and grounded on a prepared bed, exposed at low water. It remained here all winter. Guard piers of rip-rap were placed along its sides to protect it from the ice; the rip-rap was mostly broken concrete taken from the old pier, in course of demolition, situated just outside the caisson. Weep-holes were provided in the roof over the working chamber to allow free movement of water during the high tides and thus guard against any floating of the caisson when once properly grounded. As the water rose several feet each tide above this roof it was feared that if snow were allowed to accumulate ice would form and tend to strain the structure. To guard against this contingency, the caisson was entirely housed over, and as a further precaution steam pipes were led around the walls just above the roof of the working chamber, steam being supplied by a boiler on top of the caisson. It was found, however, that the steam heating was not necessary, as the interior kept sufficiently warm to prevent ice from forming.

Owing to a very late spring, actual sinking operations were not started until June 15. Since that date the work has progressed steadily, and at the time of writing the caisson has reached bedrock, some 85 ft. below the bed of the river. The material, being mostly sand, has been exceptionally easy to penetrate. The rate of progress averaged nearly 9 in. per day for the entire time. Some weeks, however, the rate has averaged as high as 15 in. per day.

Unusual Method of Sinking

Owing to the great size of the caisson, extraordinary precautions were considered necessary to provide against any unequal settlement, or any twisting or other movement of the caisson, which might tend to open up the joints and seams and consequently allow air to escape. On this account it was decided that the ordinary method of sinking, where all the load is carried on the cutting edge, would not allow the movements of the caisson to be sufficiently controlled during the actual sinking. The rather unusual method has, therefore, been employed of carrying the entire load on the bulkheads and the roof, and no load at all on the cutting edge.

The caisson was supported on 40 sand jacks, about 25 posts of 12x12-in. yellow pine, and 54 sets of blocking. The jacks and posts bore directly against the roof, while the blocking was piled under the bulkheads. When ready for a drop the blocking and posts were first removed by washing the sand from under them with a water jet; then the whole caisson was lowered by operating all the sand jacks simultaneously. The sand jacks were of simple construction, consisting each of a 29-in. steel cylinder closed at the bottom, having near the bottom two 3-in. holes with a sliding cover, and a plunger consisting of a single piece of timber fitting easily into the cylinder. The cylinder was filled two-thirds full of sand, the plunger inserted, and its upper end blocked against the roof. The operation of lowering consisted in opening the lower holes and inserting a water jet, thus washing the sand out.

These jacks worked admirably, the result being that the caisson has been sunk absolutely level and in its proper location. Before each drop a trench was excavated under the cutting edge to a depth of 2 or 3 ft., and filled with clay, which tended to prevent the escape of the air and also acted as a lubricant during sinking. This scheme was followed throughout the entire sinking and seemed to materially facilitate the operation.

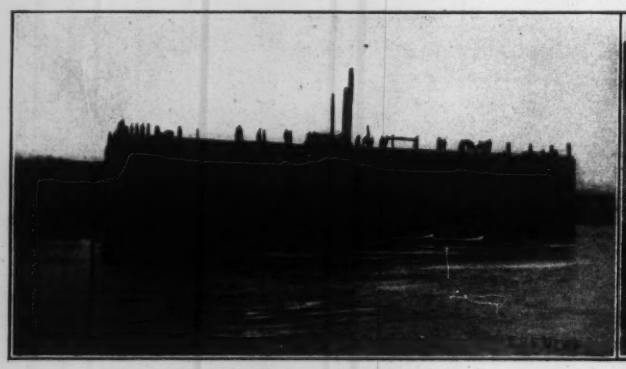


Fig. 1. Floating into Place

Fig. 2. Sinking Going On

The material encountered varied from small boulders and sand at the top to practically 95% sand toward the bottom. The sand was blown out through 4-in. pipes by means of the compressed air. Ten of these pipes were in use, and removed the fine material very rapidly. The larger material was removed through the material shafts in half-yard steel buckets. Very little blasting was necessary.

Care of Men

Owing to the great depth of the caisson, special means have been employed to enable the men to enter and leave the working chamber with the least possible loss of time and labor. An open shaft extended down to a horizontal steel lock placed over the roof of the working chamber, the lock being large enough to hold the entire shift. Communication with this lock and the outside air was made by means of a spiral stairway in the shaft. As an extra safeguard, there were four other 30-in. ladder shafts. The excavated material was hoisted out through three material shafts.

At the beginning of the work about 300 "sand hogs" were used, in three 8-hr. shifts of 100 men each. As the caisson was sunk and the pressure increased the length of shift was decreased. At 50 ft. depth, or a pressure of about 22 lb. per sq.in., a change in working hours was made to four shifts of 6 hr. each. At 85 ft. depth, or 32 lb. pressure, six shifts of 4 hr. were required. Again at 75 ft. the shifts were changed to eight of 3 hr. each. When the caisson reached its full depth of over 90 ft. below average high water, each man worked only two 1-hr. shifts per day, this being the greatest length of time that the men could stand the very heavy pressure.

Outside the caisson there were provided a bunk house, a dining room, a dressing and coffee house where the men coming out of the caisson could change their clothes immediately and be supplied with hot coffee, a hospital with cots, and a hospital tank. A qualified doctor was in constant attendance in the hospital. The steel hospital tank directly adjoined the hospital, and was connected with the compressed-air pipes. Consequently men coming out of the pressure too quickly and attacked by the "bends" could be placed immediately under pressure again before any serious or injurious effects developed.

Contractor's Plant

The caisson was surrounded on three sides by a heavy platform supported on bents. On this platform was a double line of track leading to the concrete mixers and stone yards. The skips with the loaded concrete buckets ran from the mixers to the caisson by gravity, the empty skips being hauled back by horses. Three 15-ton stiff-leg derricks placed on each side of the caisson served to deposit concrete or stone, or to hoist the loaded buckets through the material locks. On this platform was located also the pump which supplied the water to the boiler plant and for various other uses as required.

The boiler and air-compressor plant is situated near the foot of the cliff. A portion of this plant was brought over from the north shore last fall, after the sinking of the north caisson was finished, but it was increased nearly 100% in order to afford a greater reserve supply in case of breakdown and also to furnish air for the increased number of blowpipes necessitated by the greater quantity of fine material encountered in the sinking.

The compressor plant consists of the north-shore plant of five Ingersoll-Sergeant direct compressors (four with a capacity of 1250 cu.ft. and one with a capacity of 2500 cu.ft. per min.), and in addition two compound two-stage air-compressors, bringing the total capacity up to 13,100 cu.ft. per min. These two latter compressors were used only when the pressure got above 30 lb. per s.in. The air was first compressed in the low-pressure cylinder up to 30 lb., then passed through a cooling chamber into the high-pressure cylinder, where the compression was increased as desired. A smaller high-speed compressor was used for supplying air tools, etc.

In the compressor house an automatic register indicated on a diagram the pressure at all stages of the tide during the whole 24 hr. Another gage, by means of a finger operated by the tide, indicated on an adjustable scale what the pressure should be at any stage of the tide. By this means the operator, watching the finger, could adjust his compressors so as to maintain a pressure conforming to the height of the tide.

The air was led from the compressor house into two receiving tanks, which tended to absorb the sound and shock from the compressors; thence into two 12-in. mains laid in a trough of cold running water. The air entered the caisson comparatively cool; the temperature of the working chamber rarely exceeded 80° F.

The boiler plant consisted of one 75-hp., six 100-hp., and three 125-hp. horizontal boilers, and three 250-hp. Heine water-tube boilers, a total capacity of 1800 hp. A number of smaller (50-, 75- and 100-hp.) boilers were also used throughout the work for crushers, mixers, derricks and pumps.

The whole plant, as well as the working chamber of the caisson, was lighted by electricity supplied by the city. For the case of breakdown on the power line, the contractor provided a complete generator plant, located in the compressor house. It is equipped with a 30-kw. General Electric generator, capable of operating 18 arc lamps and 100 16-cp. incandescent lamps.

The concrete masonry plant is situated at the foot of cliff, which rises almost perpendicular for 125 ft. Halfway up the cliff a No. 5 and a No. 8 rock crusher are placed. The stone was quarried directly on the brow of the cliff, and one derrick could pick up the buckets of stone from the quarry and dump it into the chute leading to the crushers. Coming from the crushers the broken stone was led through a revolving screen, and thence through another chute to a hopper opening onto the mixing platform. Two 1½-yd. Smith mixers were used. The sand was brought to the brow of the cliff in cars and dumped into a large hopper, whence a chute led directly to the mixing platform. The coal was brought to the lower level in the same manner, being carried to the boiler house in side-dump cars.

The south main pier when completed will contain about 35,000 cu.yd. of masonry. For a height of 75 ft. above rock, or up to about 6 ft. below low water, it will consist of a solid mass of concrete the full size of the caisson. Above this level the shaft of the pier will start, having a solid granite face and backing of concrete. The upper 18 ft. will be of solid granite.

The concrete used for the main body of the caisson is composed of 1 cement, 2½ sand, and 5 stone. For sealing the working chamber a somewhat richer mixture was specified, 1 : 2½ : 4. Displacer stones of ½ cu.yd. and over are used in the concrete, no two stones to be closer than 9 in. vertically or 12 in. horizontally.

The work is under the supervision of a Board of Engineers, appointed by the Government, of which C. N. Monsarrat is Chairman, having associated with him Ralph Modjeski, of Chicago, and C. C. Schneider, of Philadelphia. J. D. Wilkens is Resident Engineer for the Board at Quebec, and has charge of all inspection. M. P. & J. T. Davis, of Quebec, have the contract for the masonry. S. H. Woodard, of Noble & Woodard, Consulting Engineers, New York, is Superintending Engineer for the contractors, in charge of the entire work.

NEWS NOTES. ... ...

Very Low Prices for Electric Current from central stations are reported by a correspondent of the London "Times" in connection with projected water-power plants in the north of England. We quote:

> Recent negotiations on three sites in the north of England have related to contracts for 1,500 kw. at 0.15d. (0.3c.) 4,000 kw. at 0.123 d. (0.246c.) and 10,000 kw. at 0.11 d. (0.22c.) per unit. The last-named is for an equalizing load, that is to say, the suppliers have the option of switching off when their plant is occupied in the "peak" hours. The other two examples represent electro-metallurgical works taking a continuous supply for 24 hours a day. Waste heat plays, of course, an important part in the settlement of such rates; and it must not be assumed that the day is fast approaching for the universal distribution of power at such prices for ordinary purposes from ordinary sources.

Mill Scale as a Cause of the Pitting of Steel Pipes*

By George C. Whipple† and Melville C. Whipple†

Steel seems destined to come more and more into use as a material for the construction of water conduits of certain size. For small pipes, say up to a diameter of about 3 ft., cast iron has proved most satisfactory and economical. As the size increases above this point, cast iron meets a formidable competitor in steel, for although this metal costs more than cast iron, it is stronger and the pipe may be thinner. The use of steel is increasing and it would increase more rapidly if engineers did not fear that corrosion would limit the life and perhaps cause the failure of the pipe line. Cast iron has been tried for many years and experience has shown that it has a long useful life, that may be depended upon. Some wrought-iron pipes also have lasted well. Steel pipes have been used for a shorter period. In general they too have retained their useful life, although in some cases, where they have been exposed to exceptionally severe conditions, they have given trouble.

A number of steel pipe lines have developed leaks, due to the corrosion of the metal in spots, that is to pitting. In this respect steel appears to differ from wrought iron, over the surface of which the rusting is more uniform. In fact it is this tendency to pit that engineers chiefly fear. Steel pipes almost never fail completely by breakage, as cast-iron pipes sometimes do; they merely leak through the small holes or pits produced by corrosion, so that failure would come about as a gradual process. Nevertheless, leaks are always undesirable and many leaks, or a large leak, may be serious.

The general subject of the corrosion of steel has been carefully considered during the last few years and the relative advantages of different grades of steel and iron have been much discussed by engineers, chemists and manufacturers. Some have claimed that wrought iron and steel were equally durable; some have claimed decided advantages for that form of mild steel known as American ingot iron, on account of its low manganese content and the general resemblance of its chemical analysis to that of wrought iron; while some have claimed that the presence of small amounts of copper in steel tended to make it resist corrosion.

In these discussions the importance of one factor has been very largely overlooked, namely, that of the mill scale, and as far as the use of steel for pipe lines is concerned, attention has been diverted from an important element of the problem. Although it is generally accepted by textbook writers that pitting is closely connected with the presence of mill scale and that steel from which mill scale has been removed does not pit, the salesmen of the steel companies and even the chemists themselves have much to say about the absence of manganese and the presence of copper, and very little to say about the nature of the mill scale or whether this scale is or is not affected by the purity of the metal. It is to call attention to this neglected phase of the subject that the present paper has been prepared.

*Condensed from a paper before the International Chemical Congress.

†103 Park Ave., New York City.

Occasion of the Investigation

In November, 1911, E. A. Fisher, City Engineer of Rochester, N. Y., requested one of us to undertake an investigation to ascertain the relative merits of steel, American ingot iron and wrought iron, for the construction of a 66-in. sewer outlet 9000 ft. long into Lake Ontario. This pipe is to carry the effluent from sedimentation tanks through which the sewage of the city is to be passed before being discharged into the lake at a point 7000 ft. from the shore.

Through the courtesy of Emil Kuichling, Consulting Engineer to the City of Rochester for this project, samples of steel, wrought iron and ingot iron were secured from the Allegheny Steel Co. Later, through the courtesy of C. F. W. Rys, Metallurgical Engineer of the Carnegie Steel Co. and V. Browne and T. G. Siexas, of the Allegheny Steel Co., samples of steel containing known amounts of copper were secured. Other samples were obtained at various places.

Nature of the Experiments

At the beginning a few simple immersion tests were made. Samples of the steel and iron were placed in jars of distilled water, Brooklyn tap water, salt solutions, solutions of chloride of lime, dilute acids, strong acids, etc., and observations and analyses made to determine the relative amounts of corrosion of the different samples.

The results were of some interest, as noted below, but practically speaking it was found that they could not be relied upon to tell which metal would act best when submitted to the conditions expected at Rochester. The immersion tests in tap water and dilute solutions progressed too slowly, while the use of strong solutions failed to reproduce in the laboratory the conditions that would be met in actual practice. Difficulties also arose in controlling the oxidation of the iron in the solutions after it had been dissolved in the ferrous condition. This was influenced by the volume of the solution used, the ratio of the volume to the surface of water exposed to the air, and several other factors, as Friend has well shown in his recent book on "The Corrosion of Iron and Steel."

Finding that the ordinary accelerated tests, using strong acids, were unreliable so far as the problem at hand was concerned, a different kind of accelerated test was tried, namely, one in which corrosion was stimulated by a current of electricity; that is, an electrolysis test. This was not employed for the purpose of observing those phenomena of corrosion that ordinarily occur when stray currents from high voltage electric lines find their way to a pipe line or other steel structure. On the other hand the currents employed were much stronger than would be set up in a pipe line by galvanic action, and so did not reproduce the actual conditions of service, but they enabled corrosion to take place in natural water and weak dissociated solutions under conditions similar to those that would be found in the pipe line carrying sewage. It was thought that this test would also show the manner of corrosion, as distinguished from the total amount of corrosion, better than the acid tests, and inasmuch as the real question at issue was one of pitting, and not one of general rusting, the electrolysis test seemed to be a more reliable one for the case at hand.

The results of the application of this test to various samples of steel showed clearly that mill scale has a marked influence on the uniformity of corrosion and the formation of pits. This suggested possible differences in the electrical condition of the mill scale on the different samples of steel submitted to us, and an investigation of this feature was also undertaken.

Immersion Tests

In the first experiment strips of steel (A), ingot iron (B) and wrought iron (C) as received, were put in separate beakers containing distilled water and allowed to stand at room temperature (70° F.). The distilled water contained 3.5 parts per million of CO_2 and was saturated with oxygen. After 24 hr. the water in the beaker that contained the ingot iron had less color than the other two and analysis showed that it contained less iron.

	Steel A	Ingot iron B	Wrought iron C
Area of metal wetted, sq.cm.	23	22	22
Quantity of water, cc.	370	375	395
Iron in water, mg. per litre.	45	14	36

Samples of steel (A), ingot iron (B) and wrought iron (C) were next placed in beakers containing distilled water and tap water, and allowed to stand for various periods of time during which the appearance of the plates was noted and analyses of the water made to determine the amount of iron present in the ferrous and ferric condition. Variations in the conditions were secured by using hot and cold water and by comparing strips of steel from which the mill scale had been

removed with similar strips with the mill scale left on except at the edges.

Detailed records of these experiments were kept, but the results do not warrant publication, as they were so erratic that it was evident that all of the necessary conditions of the experiment had not been properly controlled. Suffice it to say that all three metals rusted badly in all of the experiments, and that such differences as were noted between the different metals were due more to experimental errors than to the character of the metals themselves.

Generally speaking, the rusting was slightly greater in the case of the metals from which the mill scale had been removed, than in these cases of the metals on which the scale had been left, but in this comparison the differences were somewhat less with the wrought iron than with the steel or ingot iron. At the start, the mill scale on the steels appeared to exert a slight protective action, but after a few days this disappeared. On the whole the ingot iron showed somewhat smaller losses of iron than the other metals, but this was not true in all of the experiments, and the differences were never large.

Electrolysis Test

When two plates of iron are immersed in water and connected with a battery in circuit, a current of electricity will pass through the water from one plate (the anode) to the other (the cathode), and iron will be dissolved from the anode; in other words, the anode will corrode. If the plate forming the anode is uniform in composition, the corrosion will be uniform over its surface, and the loss in weight will be proportional to the current density. If the anode is not homogeneous in character, the density of the current will not be uniform over the plate, and the corrosion will be greater at some spots than at others. Thus no corrosion at all will occur over areas where some such insulating material as coal tar has been spread, but will occur in greatest degree where the raw metal is exposed.

The mill scale that is formed upon the surface in the manufacture of steel differs in chemical composition from the metal beneath it, being composed largely of iron oxides, together with some slag, and it is to be expected that its electrical resistance would be different. Moreover, the mill scale commonly occurs, not as a sheet of uniform composition and thickness, but as a series of flakes or scales (hence its name), sometimes overlapping and varying greatly in thickness. This is often evident to the eye, but may be better observed by the use of a lens.

Hence, when a sheet of steel covered with mill scale is used as the anode, it might be naturally expected that the current density would vary and that the corosion of the metal would occur, not uniformly, but in spots. Conversely, if the corrosion produced by passing a current of electricity between electrodes is irregular, it may be inferred that the scale is not homogeneous in thickness or quality; and, further, that if different plates act differently when submitted to such a test, the inequality of the character of the scale will be measured by the irregularity of corrosion.

The electrolysis test serves to indicate the *manner* in which plates corrode rather than the *amount* of the corrosion. Inasmuch as it is the pitting with which the water-works engineer is chiefly concerned, this form of accelerated test appears to have some advantage over immersion tests in which strong corrosive acids are used. In these strong acids the action is essentially a chemical one, but in the dilute solutions used with the electrolytic test, the strict chemical action is subordinated to the electrolytic form of corrosion. This test, therefore, more nearly approaches the conditions of natural corrosion in water.

It has frequently been observed that with the ordinary acid tests the purer forms of metal show the smaller losses. This is a strict chemical action in which the mill scale, as well as the iron, is dissolved away. With the electrolysis test, however, the purity of the metal itself exerts less influence, and the scale remains for a longer period of time to become an important factor, as it does in actual service.

Galvanic Survey of the Mill Scale

According to the electrolytic theory of corrosion the solution of the iron is brought about by the action of currents that are set up between different particles of the metal that have different electrical potentials, as for example, between the pure metallic iron and various impurities such as carbon, manganese, slag, etc. This has been illustrated by Walker, Cushman and others by the use of the ferroxyl indicator. Purity and homogeneity, therefore, tend to diminish corrosion. It is believed that pits in steel occur at points where for some reason or other there are particles that have greater differences of potential from that of the metallic iron or the mill scale than are found elsewhere on the sheet. Possibly this may result from segregation of the impurities during the cooling of the ingot; possibly it is due to the effect of rolling, cooling and other treatment the mill scale undergoes. It is known, at any rate, that differences of potential exist between iron and its oxides, and it seems reasonable to believe that this is a very important cause of pitting, perhaps the most important factor of all.

It seemed to us, therefore, that a study of the potential differences between the mill scale at different points and the raw metal beneath might throw light on the relative liability to pitting of the various metals submitted to us for study. On account of the difficulty of making the necessary measurements with the samples immersed in water, the simple method was adopted of connecting the raw metal of a sample with its mill scale by means of wires, and placing a very sensitive galvanometer in the circuit, the two contact poles being the rounded ends of No. 18 copper wire. The galvanometer used was sensitive to less than one ten-millionth of an ampere. It was found that when both poles were put in contact with raw metal, no current could be detected, but that when one pole touched the raw metal and the other pole touched the scale on a piece of steel plate, a noticeable current was set up, which in some cases amounted to nearly one-millionth of an ampere. Usually the current in the galvanometer circuit was from the scale to the metal, and in the sample from the metal to the scale, that is, in the direction which would tend to make the iron dissolve. Occasionally, however, the current was in the other direction. On the steel plates the currents sometimes differed greatly at points only one millimeter apart; more often, however, there were areas where the current was relatively high and others where it was relatively low. Very slight currents were found in the case of wrought iron and cast iron indicated a great homogeneity of the scale, or less difference of potential between it and the metal.

On the whole it may be said that the index of corrosion uniformity as determined by the galvanic survey of the scale, appears to give a fair measure of the probable liability of the surface of the metal to corrode in an irregular manner, that is, to pit.

Experiments with Copper Steels

That manganese, sulphur and some other impurities likely to be found in steel stimulate its corrosion is the conclusion of a number of observers. This is particularly true if these impurities are irregularly distributed throughout the mass of the metal. It is unnecessary to review the theoretical reasons advanced for this belief further than to say that they are based on the electrolytic theory of corrosion, and deal with the changes in conductivity and resistance produced within the metal by these impurities. It has been claimed that some other metallic elements when present in small quantities, have an opposite effect upon corrosion; that is, that they retard action. Chief among these is copper. Campbell* says that copper occurs as an impurity in many steels, particularly that made by the bessemer process, and may be present to the extent of 0.3 to 0.5 per cent.

Opinion seems to be divided in regard to the effect of copper in retarding cor-

*Metallurgy of Iron and Steel, p. 358.

rosion. There is evidence to show that it materially decreases the solubility of steel in sulphuric acid, but the question arises as to its effect upon the electrical properties of the steel. Sang* states that the depolarizing effect of the electronegative metals, such as copper and lead, might be expected to hasten the rusting of iron or steel. If copper protects, and if steel ordinarily contains as much copper as Campbell has stated, then it is rather surprising that the copper steels have not given better service.

The samples tested (J, K and L) contained 0, 0.23% and 0.53% of copper, respectively. The use of copper steel having been suggested for the Rochester sewer outlet pipe, some experiments were undertaken to determine its advantages, if any, for this service. These included immersion tests, electrolysis tests and galvanic surveys.

Immersion Tests with Copper Steels

Strips of the metal, 2½x8 in, were buffed and cleaned of dirt and grease, weighed and placed in glass trays, supported upon four ⅛-in. pieces of the same metal; 450 cc. of 25% sulphuric acid, enough to completely immerse the strips, was then poured into the tray. Twice during a period of 24 hr. this acid was renewed and the solution was stirred occasionally. At the end of 24 hr., the plates were removed, washed, dried and weighed. In the case of sample J, which contained no copper, the action had been violent, as evidenced by the evolution of hydrogen and the bright etched surface of the plate. Sample L, which contained the most copper, showed the least action, as far as surface appearance indicated. The following losses in weight were obtained. The loss in weight is seen to be much greater in the steel that contained no copper than in the other two.

IMMERSION TEST WITH 25% SULPHIRUC ACID

Sample	Per cent of copper	Loss in weight in grams	Area exposed in Sq. Cm.	Loss of weight in grams per Sq. Cm.
J	0	27.0	307	0.0880
K	0.23	5.4	270	0.0200
L	0.53	5.1	258	0.0198

The effect of a dilute sulphuric acid solution was also tried. For this purpose an N—50 solution of acid (i.e., about 0.1%) was used, the cleaned plates being placed in 2-qt. glass jars and covered with the acid. After 26 days the following losses of weight were found:

IMMERSION TEST WITH $\frac{N}{50}$ SULPHURIC ACID

Sample	Per cent of Copper	Weight in Grams	Area exposed in Sq. Cm.	Loss in grams per Sq.Cm.
J	0	3.00	234	0.0128
K	0.23	2.90	247	0.0117
L	0.53	3.15	231	0.0136

These results were in marked contrast to those in which the stronger acid was used, as they showed only slight differences between the losses from metals containing different amounts of copper.

Immersion tests were also made using sodium chloride solutions of two strengths, namely, 0.3% and 3%, the latter having a salinity about equal to that of sea water. The losses in weight after 26 days were as follows:

IMMERSION TESTS WITH SALT SOLUTIONS

Sample	Per cent of Copper	Loss of Weight in grams per sq.cm. 3% solution	0.3% solution
J	0	0.0015	0.0013
K	0.23	0.0015	0.0019
L	0.53	0.0019	0.0021

The general results of the immersion tests go to show that where the action is emphatically a chemical one, as in the case of the strong acid test, the presence of copper tends to reduce the action; but where, as in the tests with weak dissociated acids and salt, the electrolytic form of corrosion predominates, copper does not reduce corrosion, but on the other hand, tends slightly to stimulate it.

Conclusion as to Copper Steels

From the tests made it was concluded that the presence of small amounts of copper in steel, while they may retard corrosion by strong acids, do not serve to protect the steel against corrosion in weak acid solutions or in ordinary water. The presence of copper does not materially alter the electrical conditions of the scale, and does not, therefore, protect the metal against pitting.

Conclusion as to Ingot Iron

The samples of American ingot-iron plates tested were found to have an index of corrosion uniformity somewhat higher than that of ordinary steel plates, with or without copper, but lower than that of wrought iron. So far as failure by pitting is to be feared, therefore, the ingot iron may be regarded as somewhat better than steel; but probably not enough better to justify any great difference in cost. Exposed to severe acid corrosion, ingot iron is probably more serviceable than steel, but under ordinary conditions of corrosion in soil or water, it has only a slight advantage over steel.

Conclusion as to Wrought Iron and Steel

Wrought iron has a very much higher index of corrosion uniformity than steel or ingot iron and is much less likely to pit. This seems to be in accord with experience. Under conditions of severe chemical corrosion, sufficient to remove the mill scale and silicates, or under conditions of atmospheric corrosion, when the electrolytic form of corrosion does not predominate, there is probably little difference between the two metals.

Effect of Removing the Mill Scale

A partial removal of the mill scale tends to increase corrosion as it gives opportunity for electrolytic action between the scale and the raw metal. Scale becomes chipped off in handling and in fabrication.

The complete removal of the mill scale from steel plates increases its index of corrosion uniformly from about 50 to nearly 100 and this reduces materially the danger of pitting. The electrolysis tests made with steel plates, from which the mill scale was removed, did not show pitting in a single instance. Scale removal appears, therefore, to be a secure method of protection against pitting. To some extent it has been practised, the mill scale being removed by pickling in acid, by sand blasting etc. These processes unfortunately are expensive, but may be justified under some conditions. Steel of ordinary quality with the mill scale removed will probably withstand pitting better than the more expensive ingot iron and copper steels, and just as well as wrought iron itself.

It is possible that some method may be found to modify the mill scale during manufacture so as to make it more uniform or improve its electrical condition, or make it more easily removable. It certainly seems as if the next step in advance in steel manufacture lies in securing a better control of the character of the mill scale. An extended study and series of experiments on the formation, composition and electrical properties of scales produced at different temperatures might determine the conditions that must be controlled to produce a satisfactory scale. If a satisfactory scale cannot be obtained the only apparent remedy for pitting is scale removal.

Summary

It is the opinion of the authors that the experiments and observations outlined in the foregoing pages warrant the following general conclusions relative to short time tests for corrosion, and to the part played in corrosion by mill scale.

(1) Accelerated corrosion tests of iron and steel plates made by immersion in strong acid solutions are of little value as indicating the probable corrosion of the metals in water under conditions of actual service.

(2) Accelerated tests made in running water by the use of a current of electricity give results that indicate the *manner* in which the plates will probably corrode in service; that is, whether by pitting or by general corrosion.

(3) When steel pipe lines fail, they do so by the formation of numerous pits that ultimately form holes and cause leaks. An important factor in the formation of pits, commonly recognized but by no means fully appreciated, is the mill scale.

(4) Steel plates that pit badly under the electrolysis test when the scale is left on do not pit after the scale has been removed.

*Sang, Corrosion of Steel, p. 37.

(5) A galvanic survey of the mill scale, made by determining the current that will pass through a sensitive galvanometer placed in the circuit of wires that connect the mill scale with the metal beneath, gives results that differ materially for wrought iron and steel, and from which an index of the uniformity of corrosion may be calculated that bears a general relation to the liability of the metals to form pits.

(6) The electrolysis tests and the galvanic survey show that wrought iron has a less tendency to pit than steel, and that American ingot iron is intermediate between the two, but resembles steel more nearly than it does wrought iron.

(7) Steels containing copper differ but slightly among themselves and from steel that contains no copper, in their tendency to form pits.

(8) To protect steel or ingot iron against failure by pitting, the best remedy is the removal of the mill scale. Efforts should be made to reduce the expense of doing this, or to modify the character of the scale during its manufacture. This appears to be the direction in which future improvements in the manufacture of steel plates for pipe-lines should lie.

A New Design of Mechanical Gas Producer*

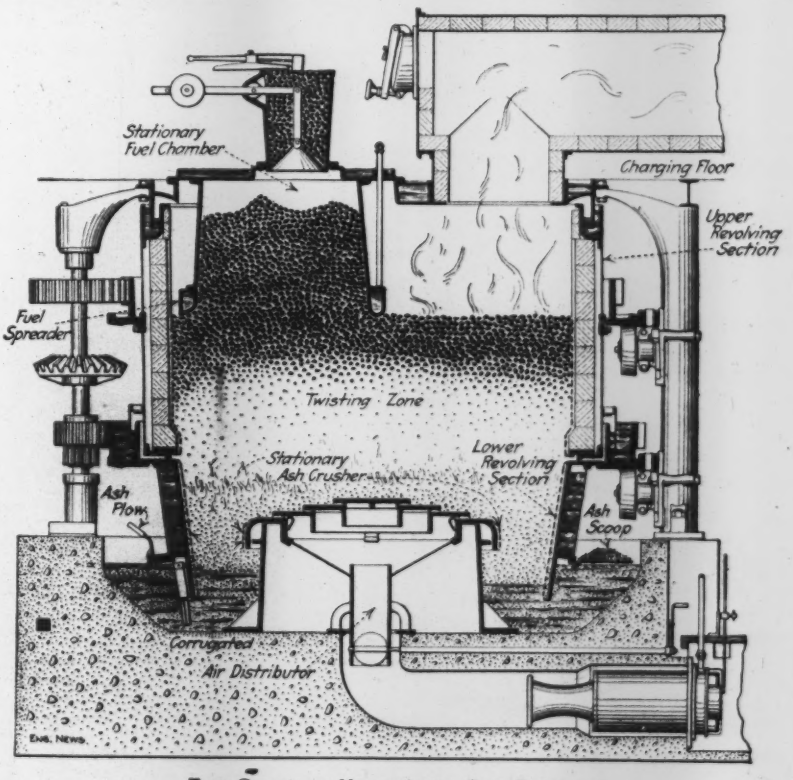
A new design of gas producer of the rotating type, recently invented by W. V. Chapman, of New York City, presents features of interest. It is reported that this type as built by the C. & G. Cooper Co., of Mt. Vernon, Ohio, for the Chapman Engineering Co., has met with success in trial service, and that important sales have been made for regular use.

This design is an all-mechanical type, making necessary no manual assistance in firing, in breaking up the fire bed, or in removing the ashes. A section through the machine is shown in the accompanying figure. It is seen that fine and coarse coal can be fed simultaneously without separation from a stationary fuel chamber supported at the charging floor by the columns which carry guides for rotating parts. The fuel-chamber capacity is 1000 lb. of coal—enough to last for about half an hour. The lower edge, which is in contact with the fuel bed of the producer, is water-cooled. The main portion of the shell revolves so that fresh parts of the fire bed are continually coming under the fuel chamber, which feeds sufficient coal to bring the surface up to a level with the bottom of the feed. The lower edge of this fuel chamber is beveled as shown so as to force down the fresh fuel deposited as the bed revolves away. It is claimed that this action feeds nonuniformly and as needed in the more burned-out spots, checking the formation of holes and crevices in the surface—points at which more fuel is needed than elsewhere. The lower part of the shell, carrying mostly ashes and nearly burned coal, revolves in the same direction as the main shell, but at a slower speed, so that the fuel bed is continually being sheared apart. This is claimed to prevent chimneys and cavities by shearing them off and filling them up as soon as they begin to develop. Since clinkers are formed on the walls of chimneys and cavities, it is claimed that clinker elimination is a consequence of the shearing action which prevents large cavities.

Projecting up into the fuel bed from the foundations of the producer, is a stationary air distributor and corrugated ash crusher. The lower part of the revolving shell is also corrugated on the inside and the effect of its rotating about the air distributor and ash head is to crush any lumps which form, allowing them to drop down into the water seal. After the ashes find their way here they are forced out and up by plows and are automatically scooped up and discharged.

Three producers are reported to have been in operation since November, 1911, at the works of the American Steel & Wire Co., Cleveland, Ohio. The average results of two weeks' tests on one unit are claimed to have shown 150 B.t.u. per cu.ft. and a maximum variation above and below of but 2.54%. The percentage of CO_2 was 6.54%; CO was 21.91%; hydrogen, 17.1%; CH, 2.70%, and illuminants, 0.51%.

It is claimed that much of the success reported is due to care in the design of details; for instance, supporting rollers are chilled castings, ground and running on high-carbon steel pins provided with brass bushings. Separate rollers are used to take side thrusts and all rollers are mounted in pairs set in equalizing yokes. The bearings are provided with large oil wells filled with waste after the scheme for journals on railway cars. The faster traveling gears run in oil.



THE CHAPMAN MECHANICAL GAS PRODUCER

*From information supplied by the Chapman Engineering Co., Mt. Vernon, Ohio.

The Kiplingesque Style in Technical Writing—A steam shovel at work in the New York City subway excavations in thus described by a metropolitan newspaper reporter:

Then down below could be seen a steamshovel at work. To watch it nose into the great bank of rock and earth before it in that dim light made one think of some great monster feeding at its ease. Its rickety caboose swayed like a huge body, and every now and then its great shovel would shoot out and move a giant lip. Into the bottom of the mound it bit, and as its mouth closed on a pile of stones it slowly raised its head. It swung it from side to side as though it were in the act of swallowing, and then turned back again to the feast. As a matter of fact, the control that has been established over these steam shovels is so marvelous that they can do almost anything that a being endowed with intelligence can accomplish The scoop is provided with four sharp teeth, made of hardened steel, and these grind into a pile of earth and then close up with a snap, just like a mouth etc.

An Early View of the Culebra Cut on the Panama Canal

Many engineers who have visited the Panama Canal works during the past few years must have wondered how the valley through which the Culebra cut is being dug appeared to the eye before the great task was begun.

The photograph reproduced on this page shows it, not indeed in its original state of nature, but as it appeared shortly after the French engineers under De Lesseps had begun work. The date of the photograph is 1885 and the site from which it was taken is the top of Contractor's Hill, which marks the summit of the Continental Divide. The camera is pointed down the Rio Grande valley, and shows, in fact, the valley through which the western third of the Culebra cut has since been excavated.

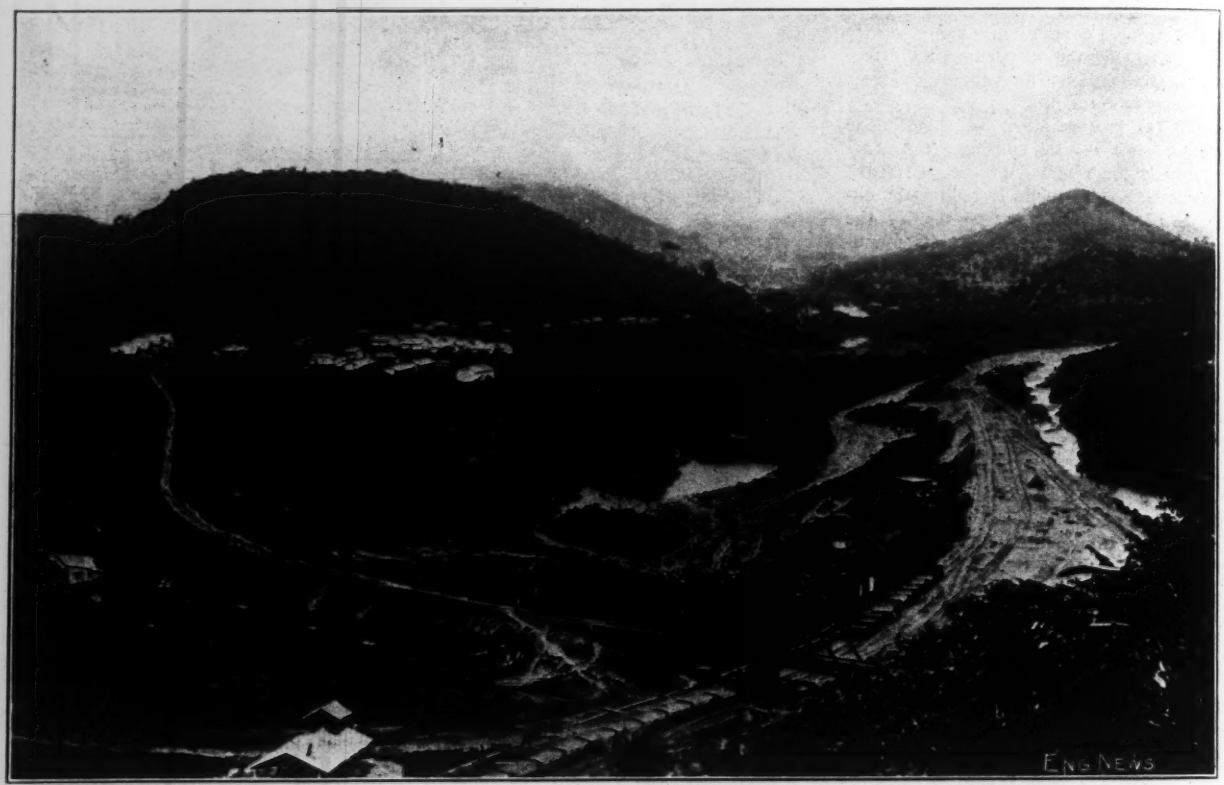


FIG. 1. A VIEW OF THE EARLY FRENCH WORK ON THE PANAMA CANAL EXCAVATION IN THE CULEBRA CUT. FROM A PHOTOGRAPH TAKEN IN 1885 FROM THE TOP OF CONTRACTORS' HILL LOOKING DOWN THE RIO GRANDE VALLEY
(Photo by Underwood & Underwood, New York.)

To show the comparison between "then and now," we reproduce on the opposite page a photograph taken very recently (Aug. 17, 1912), from approximately the same position; the camera, however, was a little farther back, as may be seen by the relative size of the topographical features. The Panama Ry. bridge over the canal, just above the Pedro Miguel lock, may be made out in the distance. A comparison of the two views gives some idea as to the magnitude of the huge furrow which has been gnawed through this valley by the sharp teeth of American steam shovels during the past half-dozen years.

Car Couplers for Interurban Electric Railways*

The principal factor of the requirements appears to be the feature of intercoupling with M. C. B. couplers, based on the necessity of interchange of rolling-stock between steam and electric railways.

The requirements formulated by this committee in 1911 comprised the features of a radial drawbar, provision for successful operation over irregularities of grades, and the limiting of lateral movement in the coupler heads. These not only conflict with M. C. B. specifications, but offer to the interurban roads requiring these features, arguments which are brought into the question of the interchange of rolling stock with steam roads. As, for instance, in the hauling of two steam railway cars, coupled together, over the interurban lines, these cars being equipped with rigid M. C. B. couplers, in which the special features of radial drawbars, etc., are absent. Also, on the other hand, where the interurban car equipped with a radial drawbar is to be hauled by the steam road, the feature of locking the coupler in a central position to conform to M. C. B. requirements is hardly practical except in emergency cases.

So long as the specifications for couplers for interurban cars must embody the factor of intercoupling with M. C. B. couplers, in order that rolling stock may be interchanged, only M. C. B. specifications for couplers and drawbars can be considered as a standard by the electric railways. The interurban roads contemplating the regular interchange of rolling stock with connecting steam railroads, other than those who are already doing so, will necessarily be obliged to arrange their trackage so as to permit of the operation of two or more steam-railway cars coupled together, and with this accomplished, there are no requirements of specifications other than the M. C. B.

The majority of interurban roads, however, as observation has revealed, generally operate their own rolling stock in trains, frequently cars from connecting interurban lines and occasionally a steam-road car over their private right-of-way but seldom in city terminals. Yet rarely if ever are their cars operated over a

*From the report of the Committee on Equipment, presented at the annual meeting of the American Electric Railway Engineering Association, held at Chicago on Oct. 7 to 11.

connecting steam road. This condition is regarded as typical and one which will exist until a time when increased business may bring about the regular interchange of rolling-stock with steam roads, and under which conditions the interurban road or roads involved will have to conform to the current M. C. B. coupler practice and make such changes in their trackage as will permit of the use of these couplers.

While there are numerous operating disadvantages to the M. C. B. coupler in the radial form, for the interurban roads which may be classified under the conditions noted in the foregoing paragraph, an M. C. B. radial coupler would best meet the requirements of the majority of interurban roads, in view of the occasional haulage of steam-road cars, and more particularly for the reason that the M. C. B. coupler head lends itself toward interchangeability of radial couplers. The committee therefore recommends the following specifications for M. C. B. radial couplers:

SPECIFICATIONS FOR COUPLERS FOR INTERURBAN CARS, WHERE THE INTERCHANGE OF EQUIPMENT IS INVOLVED

1. All couplers must be made to automatically couple by impact with M. C. B. and all other types of M. C. B. contour couplers, whether used by steam or electric roads; also to uncouple without the necessity of a man going between the cars.

2. A device should be adopted for holding couplers on center within the required limits when inter-coupling with cars of steam railways.

3. An open knuckle for shackle-bar connection should be used.

4. The draft gear, where possible, should meet M. C. B. requirements, and the drawbar anchorages should be equivalent in strength to M. C. B. equipment and requirements.

5. Couplers must not uncouple when cars are being pushed around a curve of 35 ft. center radius.

6. There should be an arrangement to release and open the knuckle without requiring the operator to pass between the cars.

7. The face of the knuckle vertically should be 16 in. maximum.

8. The height of drawbar center should be 31½ in. minimum and 34½ maximum above the head of the rail.

9. The coupling center of couplers must have a minimum projection of 6 in. beyond buffer faces at any point between the working limits of couplers.

10. Couplers should be placed on both ends of the cars.

Repairing a Bridge Pier Over 600 Years old—During the excavations undertaken in connection with the new hydro-electric works on the Dee at Chester for the purpose of lowering the floor of the river and increasing the area of the hydraulic section, the foundations of two piers of the old Dee bridge were found to be in an unsatisfactory condition, and measures are being taken by the Corporation for the preservation of the structure, which dates from 1280. Sir Francis Box, who has been consulted, recommends that the loose material between the stones should be removed and that the interstices should be filled up with cement by means of a grouting machine.—London "Times," Oct. 9.

FIG. 2. VIEW TAKEN AUG. 17, 1912, FROM APPROXIMATELY THE SAME POSITION AS FIG. 1, AND IN THE SAME DIRECTION, SHOWING SOUTHERN THIRD OF CULEBRA CUT APPROACHING COMPLETION

(Photo by Underwood & Underwood, New York.)

The Displacement of the Horse by the motor for pleasure vehicles is shown in the following traffic census taken on Sunday, Sept. 1, on Sheridan Road Boulevard, Chicago, between 7 a.m. and 9 p.m.

Kind of Vehicles	No. of Vehicles	Estimate of total weight, tons
Horse-drawn pleasure vehicles, estimated ½ ton each	87	43
Bicycles estimated at 150 lbs.	187	14
Motor Cycles, estimated at 300 lbs.	550	82
Automobiles, estimated at 1¾ tons	6,765	11,838
Total	7,589	11,977

The street is 40 ft. wide between curbs and is paved with bitulithic pavement, which has been down seven years and we are informed has received no repairs since it was laid.

A Symposium on Caisson Disease

BY HENRY JAPP, HERMAN VON SCHROTTER, T. KENNARD THOMPSON, SEWARD ERDMAN, PETER BASSOE AND J. J. R. MACLEOD.

The possibility of injury to workers under high air pressure has been a serious problem in compressed-air caisson construction. The following symposium on the state of the art and possible improvements is by engineers and physicians who have made long studies of the subject.

*Official abstracts of papers presented before the International Congress on Hygiene and Demography, Washington, D. C., September, 1912.

Caisson Disease and Its Prevention

BY HENRY JAPP*

Our ignorance of caisson disease in the past has resulted in an increasing cost of operation by bringing about reduced hours of labor to minimize the chances of disease, by increasing wages to overcome the fear of disease, and by limiting the supply of labor through medical exclusion to prevent disease. Without doubt men are built to undergo pressure changes, as it is possible on the earth's surface to experience a range of pressure from 17½ lb. absolute in the deepest mine to 5 lb. absolute on the highest mountain, or a fall of 71½%, which is the equivalent of decompressing from +36¾ lb. to atmosphere.

Paul Bert's mechanical theory that caisson disease is caused by the blood and tissues absorbing nitrogen under pressure, which escapes as bubbles during and after decompression, is generally accepted, and cure by decompressing the liberated bubbles and prevention by slow decompression are universal. E. W. Moir's medical airlock on the Hudson Tunnel reduced the death rate from 25 to 1%, and on the New York East River tunnels this, combined with slow decompression, gave a death rate of 0.19%.

Dr. Haldane's stage decompression method prevents fatal cases, and provides safety for divers in 210 ft. of salt water, or +92.4 lb. This method consists of never permitting the maximum air saturation of the body on decompressing to be higher than 2.3 times the pressure in the airlock or than the atmosphere on emerging. This permits a quick drop to half the absolute pressure on entering the airlock, which accelerates the desaturation of the body much more quickly than the uniform method of decompression. In very deep diving, where the period of immersion is not great, the decompression period is not excessive, but in caissons and tunnels the immersion is comparatively long and the decompression period required appears to the writer to be too conservative and lengthy for practical purposes. On the East River tunnels 23,000 individual decompressions were made from +40 lb., with a modified stage method on Dr. Haldane's principle, in 48 min. without fatal or serious cases, leaving the maximum air saturation of the body on emerging at +27 lb. From this result the writer has drawn up a table for decompression from tunnels. The methods of caring for the workmen are described and the regulations under which they worked are embodied in an appendix, as well as the proposed rules to be observed, which were submitted to the Commissioner of Labor of the State of New York by 21 engineers, doctors, and contractors.

The effect of the workmen's mental condition is mentioned as a possible influence on their susceptibility to caisson disease, just as fear is said to make men subject to yellow fever. Dr. Leonard Hill's conclusions from his recent experiments are given, and the desire is expressed that the International Congress on Hygiene and Demography may draw up a table for decompression as a guide to future legislation.

*Engineer with S. Pearson & Son, Incorp., 507 Fifth Ave., New York City.

Note on Caisson Disease

BY T. KENNARD THOMSON‡

Sewage-polluted soil in the Harlem River caissons caused much trouble with caisson disease at light pressure of compressed air which in pure air would have given no trouble.

Air rendered impure by workmen caused trouble. New York is taking a great risk by polluting its rivers and bays.

‡Consulting Engineer, 50 Church St., New York City.

Propnylaxis of Labor in Compressed Air

BY DR. HERMANN VON SCHROTTER†

The experimental results of recent years have enabled us to understand better the *pathogeny* of the various symptoms observed after rapid decompression. We have also more correct conceptions in regard to the rôle of oversaturated liquids, and of the *conditions* under which *the release of gases* in bubble form takes place in the organism.

The *decompression* must take place, so that, while more rapid in the beginning, it slows down gradually and in proportion to the degree of saturation. In all cases a decompression in the contrary sense seems injurious. The muscular work facilitates, by its effect on the circulation, the elimination of gas during (and after) the discharge.

Oxygen as a prophylactic and therapeutic means should, according to what we have already at another time insistently advised, enter more strongly into the practice of decompression. The use of oxygen could shorten the necessary duration for effecting a decompression unattended by danger.

Duration of Stay and Decompression—After labor under an over-pressure of 1 to 1.5 atmospheres, which need not be limited as to time (that is, 6 to 8 hr. shift is not too long), decompression may be effected in 10, that is, between 5 to 15 minutes, in which latter case initial acceleration of the decrease of pressure appears proper, after labor under an overpressure of 2 atmospheres, decompression to 0.5 atmosphere in 3 min. Overpressure to be effected and then at an even rate of 0.1 atmosphere, in not less than 4 min. After labor under an overpressure up to 3 atmospheres, work must be shortened to 3 to 4 hr. Concerning decompression: first decrease of pressure in 3 to 5 minutes to 1.5 atmospheres. Overpressure, then decrease of pressure at the rate of 0.1 atmosphere, in not less than 4 min., or gradual decompression by means of an air-lock, with about one-half, then one-quarter of the working pressure, with regard for physical activity, avoiding of harmful refrigeration (use of oxygen). In every construction work in which an overpressure of 1.5 atmospheres is employed, there must be recompression air-lock.

How to arrange the prophylactic measures in each individual case depends upon the particular circumstances of the work, upon the requirements which labor in compressed air demands. In the technical preliminary measures for a construction to be built under compressed air, a physician, well versed in the matter, should therefore be consulted who, on the basis of the technical and local elements entering into the work, should determine the special regulations, based on the facts established, and correctly harmonize stay, pressure and decompression in order to reduce, as far as possible, the quota of danger. These, in such case *obligatory* measures shall from the beginning have to be arranged in such a way that they will take into account the possibility of a wider basis as the work progresses, etc.

The *slow decompression*, with a rapidity accelerated *in the beginning* as proposed by Haldane is preferable to a uniform decrease of pressure. Oxygen as a prophylactic agent should be used

†Vienna, Austria.

more than heretofore, especially in respect of the diver.

Acute Effects of Caisson Disease*

By Seward Erdwan†

Caisson disease, in its acute onset, is the most dramatic of occupational diseases. The sources of material for this paper were chiefly the 3692 cases among the 10,000 men on the East River Tunnels Contract, New York.

Aëropathy is suggested as a name to include the various terms: "Compressed-air illness," "Caisson disease," "Divers' palsy," "Bends," etc. The disease is solely the effect of decompression.

Phenomena of Compression — These are not symptoms of aëropathy, but the mechanical or physiological effects of compression. We do not believe that pallor of the skin occurs unless from fright. Nor is there any constant alteration in the blood-pressure, volume or rate of the pulse, nor in the respiration rate; nor in amount of urine or sweat excretion. The well established effects include: Pressure upon the membrana tympani; rise of body temperature and sweating; resistance to expiration and phonation, which renders whispering impossible, whistling difficult and causes a sensation of numbness of the lips; change in quality of voice; exhilaration.

Phenomena of Decompression—Chilling of the body. Crackling sensation in the ears.

Symptoms of aëropathy, the result of decompression. Time of onset, early; few cases delayed over three hours. Commonest types: (1) Pains. (2) Vertigo or "staggers." (3) Cerebrospinal. (4) Dyspnea or "chokes." (5) Prostration and pains. (6) Unconsciousness and collapse. (7) Fatal cases from groups 3, 5, 6.

The Remote Effects of Caisson Disease

By Peter Bassoe, M. D.‡

This paper mainly consists in a further elaboration of the material investigated under the auspices of the Occupational Disease Commission of Illinois during the year 1910. The more important cases have been re-examined and subjected for more detailed examination, especially of the ears (aided by Dr. G. W. Boot), and by the X-ray. The most common persistent results seem to be deafness and tinnitus. A number of the patients now present several of the ordinary symptoms of caisson myelitis and accompanying physical signs. Especial attention is given to a few cases in which the histories and findings point to the production of chronic, and to some extent progressive, disease of bones and joints. Thus, one patient presents typical clinical and X-ray findings of arthritis deformans of the hip, the symptoms having come on suddenly thirteen years ago, after working two shifts in air at pressure of 30 lb. Another patient, in addition to signs of cord disease (not tabetic), has developed trophic changes in the bone, causing a type of fragilitas ossium. Attention is called to a large number of men giving history of paralysis and other serious manifestations years ago and now well and free from physical signs of disease. Alcoholism very prevalent among men studied.

*Some of the more technical medical features have been omitted.

†Adjunct Assistant Surgeon to Bellevue Hospital, New York City.

‡Rush Medical College, Chicago, Ill.

The Hygienic Physiology of Work in Compressed Air

By Prof. J. J. R. MacLeod*

Although it is now a well established fact that the symptoms of caisson disease and divers' palsy are due to the sudden liberation of bubbles of nitrogen in the blood and tissue fluids, on account of too sudden decompression, there are several peculiarities regarding the conditions which influence the safety of decompression about which there is still a certain degree of uncertainty. This is the case more particularly with regard to: (1) Whether the decompression should be uniform or in stages; (2) how long it should take in proportion to the time of the shift and the pressure employed; (3) the degree to which the breathing of oxygen increases the safety of decompression. Although, as insisted on by Haldane and others, it is no doubt the case that "the absolute air pressure can always be reduced to half the absolute pressure at which the tissues are saturated without risk" yet, in practice, it has not been found that the method is in any way superior to that of gradual decompression.

The time that should be taken in decompression depends on the length of the shift in the caisson because the saturation of the remoter parts of the body with nitrogen continues for a long time after this has been attained in the blood and the more accessible tissues. Tables indicating what time should be allowed have been prepared by Haldane and by Japp. These will be discussed, particularly with regard to their practicability.

The advantages of breathing oxygen are not only that it accelerates the diffusion of nitrogen out of the lungs and, therefore, out of the blood; but, if symptoms have already appeared, it supplies enough oxygen to keep life going when the circulation is dangerously obstructed by nitrogen bubbles. In using oxygen at higher pressures, its toxic action must, however, be kept in mind.

Recompression, either by placing the caisson worker in a pressure chamber or by having the diver descend again to a certain depth whenever the first symptoms appear is by far the most efficient treatment, as both experiment and the experience of engineers testify.

On account of the heat and the high relative humidity of compressed air, the worker in a caisson is under conditions which tend to lower his efficiency. Not only this, but his appetite is likely to suffer and his general condition after some time to deteriorate so that he becomes liable to infections if not to caisson disease itself. The caissons should, therefore, be well ventilated and the wet bulb thermometer kept as low as possible. In the choice of men for caisson work attention should be paid to age, body weight and fatness, and while engaged in the work the men should be kept in good training.

*Western Reserve Medical School, Cleveland, Ohio.

Castor Oil in India—A few years ago castor oil was the universal lubricant in India for both internal and external lubrication, but as engineers became more enlightened on the subject of lubrication generally, castor oil for internal lubrication was discarded. ["The Engineer," London, England, Aug. 9, 1912.]

Effect of Meters on Water Consumption—The statistics given in the accompanying table are a concrete example of the effect of meters on consumption, and should commend itself forcibly to all citizens, in that it proves conclusively the fact that to meters more than to any other factor credit is due for checking willful or neglectful waste of water. A pumpage of 141 gal. per capita in 1907 has been reduced to 53 gal. per capita today without depriving any person of this essential element. Dire results were predicted by fearful people just four years ago when the meter system was proposed, but today those who were formerly antagonistic are firm believers in this plan of delivering water to consumers.

EFFECT OF METERS ON WATER CONSUMPTION, HOUSTON, TEX.

Year	Number of Meters	Percentage of Consumers Metered	Average per Capita Pumpage	Population City Census
1907	108	1.5%	141 gal.	73,017
1908	303	4.0	122 gal.	79,464
1909	1903	21.0	106 gal.	82,542
1910	4556	48.0	82 gal.	95,930
1911	8131	82.0	53 gal.	109,594

A total of 2,125,981,520 gal. of water was pumped as reported by the Chief Engineer for the year 1911, as compared to 2,859,091,610 gal. for the year previous. This represents a saving of 733,110,090 gal., notwithstanding several large conflagrations which occurred during 1911.

This fact deserves more than casual notice, as it is an economy that means more to the city than is represented in mere figures. It is a supply of pure water held in reserve for future use, insuring at the same time a lease upon the practical capacity of the wells for a greater period of time.—[From the Annual Report of the Water Department, Houston, Tex.]

Conference of Irrigation Managers at Bozeman, Montana

(CONTRIBUTED)

The first of a series of 1912 conferences of operation and maintenance men in charge of large irrigation projects was held at the Agricultural College at Bozeman, Mont., Oct. 17 and 18. There were present the managers of the principal irrigation systems in the northern part of the arid region, the faculty of the Agricultural College and others interested. The object of these conferences is to bring together the managers who have immediate care of large irrigation works, those serving water to several hundred or several thousand water users, on which it is necessary to adopt and follow carefully considered rules and regulations.

The discussions brought out the fact that the present is a time of transition in many parts of the arid West from the old, easy-going way of handling irrigation canals to more effective modern methods. In cases where the farmers have gradually built the works and where each man is well acquainted with his neighbor and with the operations in general, there is possible an informal and cheap way of distributing water between neighbors, each of whom has learned through years of experience something of his duties and responsibilities. This is not possible in the case of the larger systems built by corporations or by the government, where hundreds of farmers representing various types of experience, nationality, and religion, are brought together from all parts of the country. These men have not had the advantage of working together, they are not even acquainted with each other's ideas or methods, and through ignorance are often highly prejudiced against each other, so that there is none of the coöperative spirit which has characterized the building of the earlier irrigation canals. They have not learned by trial and failure the dangers of lack of team play in handling the distributing canals, and cannot acquire this experience readily because, with the canals already built for them, it would not be safe to attempt to gain experience in this manner. Where a half-dozen pioneers have joined together in building a small irrigation canal, if mistakes in management were made at first, no very large amount of money or property was involved, and experiments might be made which would be fatal to life and property if undertaken with a large, fully constructed canal.

In the older smaller irrigation systems the individual shareholders have fought or agreed among themselves regarding the distribution of the water until, by constant attrition, they have developed a relatively smooth procedure. They have expended in these controversies and in litigation as a rule more than their canals have cost. Each year the stockholders now meet together, criticize and condemn the present management, elect new directors, and adjourn until the next meeting. These new directors, all of them experienced in past controversies, generally settle back to about the same course of procedure, employ usually the same manager, and continue largely in accordance with unwritten understandings.

Such an easy-going course is impracticable with the large modern works. The users do not have behind them nearly a generation of experience, and the directors they elect are frequently newcomers, village lawyers or real estate men, many of whom have not had any considerable experience in irrigation. Hence it results that there must be an entirely distinct method of management and a development of a system which will guard the delivery of water to the individual in spite of the fact that the great body of these individuals, have not had experience in irrigation or even in agriculture.

The lesson learned in studying the history of the irrigation systems is that for success, the control of all large works must be in the hands of a strong, capable manager, having no personal or private interest in the canal, but devoted solely to the carrying out of certain policies designed to secure the greatest good to the greatest number, and at the same time assuring the delivery of water to the owner of the poorest and smallest farm on the project.

To bring about this condition is the constant effort of every well developed organization. In some cases, despairing of adjusting the warring factions under these systems, recourse is being had to outside corporations organized for the express purpose of making contracts to operate and maintain these irrigation systems in such a way as to be wholly impartial and to guarantee the upkeep of the work and the economical delivery of water. By having as manager a man employed from outside of the area and one who cannot be influenced by local politics, it has been found possible to operate these enterprises with a minimum of friction and a maximum of efficiency.

In the case of the modern irrigation systems which are now being built by private and public capital, it is evident that some such course must be followed, and that it is not possible to immediately commit the details of operation and maintenance to the land owners. To do so is to invite on a larger and more disastrous scale the same evils which are rampant in the control of smaller irrigation canals. There must be a strong central organization headed by a manager who is removed from the danger of being influenced by individual water users, and who has enough assistants, responsible directly to him, to enable him to carry out effectively the general plans and policies.

The condition may be illustrated by comparison with the growth of a railroad system. In the early days the small local railroads, serving a community where every one knew his neighbor, could start out a train stopping along the line to accommodate each passenger, and delivering packages at each crossroad, or wherever a signal was waved. They were simply neighborhood affairs, operated according to the convenience of the conductor and his friends.

When these little railroads became consolidated and formed portions of a main-trunk system, serving the needs of thousands of people at remote distances from each other, it became necessary to establish a more rigid schedule and endeavor to adhere to this. It was no longer possible to stop at every siding. There were greater and more remote interests to be guarded, and while the little local railroad might be operated at very small expense and large risks might be taken in the maintenance of the road-bed, these smaller savings and conveniences could not be tolerated with heavier trains and higher speeds.

So it is with a large irrigation system. The risks which may be taken with a small body of water would be criminal in connection with the flow of a canal carrying an entire river. Hence it is being recognized that the operation and management of irrigation canals, instead of being a sort of neighborhood affair, must be a distinct profession; the men employed on it, instead of being local farmers picked up from day to day, must be skilled men whose entire time is devoted to the work and who have especial qualifications for it.

Under the smaller canal systems built by the farmers themselves, if a break occurred every one of them was ready to drop other work and repair the break. Under the big modern irrigation systems, if a break occurs 20 or 30 miles away, no one feels that it is his immediate duty to help in the repair; the management must somehow get together enough men. Hence, as the size of the system increases the difficulty of obtaining necessary labor at critical times also increases, and there must be available a trained force in the same way that a railroad maintains its section foremen and extra hands.

At the operation and maintenance conference these conditions were discussed and attention was directed largely to the necessity of the agricultural colleges of the West training young men for the minor positions in canal operation, not especially as engineers, but as agriculturalists and irrigators.

It appears that the tendency has been to devote the college work too closely to the construction side of irrigation work, the building of dams, canals, power plants, and intricate machinery. What is most needed now is a large body of young men brought up on the farm, who

have had a thorough education in the theory and practice of agriculture, in the handling of the soil, and in the application of water. These men are needed to begin at the bottom in irrigation management to fill the places of canal riders, distributing water from day to day to the farmers, covering a length of canal of perhaps 15 or 20 miles, and incidentally to their main work of setting the gates, keeping in touch with the farmer and indirectly giving such advice as may be helpful to the less experienced irrigators.

In the past these places have been filled largely by local men picked up for the purpose. The very fact that they have been available shows usually that they are not successful farmers; otherwise they would be too busy to accept such employment. While it has been necessary to operate systems of considerable size with men obtained in this way, the results prove that as the large irrigation systems develop, there must be provided a body of trained men from whom to select these canal riders, as their position is one of considerable responsibility. Upon them depends primarily the success of the farmer.

From the more capable of these canal riders will be selected assistants to the superintendent of the canal; and as opportunity arises these assistants in turn become superintendents and finally manager of the entire system. There is thus an opportunity for energetic, tactful, and well qualified men to begin as canal riders and be advanced upon meritorious record to the responsible management of great systems distributing water to thousands of farms.

It was this phase of the matter which was made most prominent at the Bozeman meeting, and assurances were given that the College would aid in the development of young men of this type, as it is appreciated that with the rapidly growing systems in Montana and elsewhere, there will continue to be more and more demand for canal riders, superintendents, and managers.

Attention was also given at this conference to more technical details, such as the measurement of water to the individual farms, methods of recording these, and ways of rotating the flow of water in the laterals.

It was brought out that in many parts of the country there has grown up the pernicious practice of turning to each farm a small continuous flow of water which the farmer can utilize as he sees fit or permit to run to waste. As a result the sub-soil has been saturated and thousands of acres of what were formerly the best farms have been reduced to swamps by the seepage from higher lands. The amount available at any one time to any one farm in most cases has been too small for economical handling, and not only has there been waste of water, but also waste of time of the farmer in trying to conduct the small irrigating head from point to point. The farmers themselves in many cases have joined together to establish a system of rotation by which one man takes his neighbor's water for a few hours or days joined with his own, and quickly irrigates, then turns the entire flow to his neighbor, and so on, shutting off the water from his own farm and allowing the soil to dry out to the proper degree and giving time for the ground water to subside.

This system of continuous flow and individual exchange of water has become in time quite complicated. In some of the older canals it has worked out fairly well and the loss of water and of land through seepage has been kept down; but in a large system supplying 50,000 or 100,000 acres of land it is impracticable to permit this haphazard arrangement and it is necessary at the outset to make arrangements for systematic rotation, by which each farmer may be assured of a full irrigating head during certain days and then another period when he will not have the water and can devote his entire time to cultivation.

The provision of such a system of rotation is by no means easy, and its adaptation to the needs of the crops requires close coöperation between the farmers and the management. Some of the irrigators, accustomed to the free and easy ways of the old continuous flow, are resentful of the modern system and will not coöperate, even declaring that they will see their crops burn up before they will adjust their methods to the rotation agreed upon with their neighbors. Great tact and forbearance is, therefore, required on the part of the canal riders and the management in general, to deal with these cases and to persuade them to use the water at such times as it may be available and when the fields obviously will be benefited.

The old methods which must be gradually done away with were based upon a continuous flow of so many miner's inches or cubic feet per second per acre of land. The modern ways are based upon so many acre-feet of water applied during the year to each acre of land. There is a common saying that the irrigator needs an inch, or half an inch, to the acre; that is to say, a miner's inch flowing continuously is supposed to be needed for each acre of land. The miner's inch varies in quantity and in different localities. Forty miner's inches or fifty miner's inches, or some intermediate amount is equivalent to a cubic foot per second. The latter amount flowing continuously for 24 hr. will cover an acre to a depth of nearly 2 ft., and for 100 days, or about the irrigation season, will cover 100 acres to a depth of about 2 ft.

In some of the Western states it is considered that a cubic foot per second flowing continuously is required for 70 acres, but where water is more economically used it is claimed that 1 cu.ft. per sec. is enough for 160 acres. All of these estimates, however, are based on the theory of continuous flow, which is usually destructive to economical use of water. Strenuous efforts are being made to adhere to the measurement of direct quantities, namely, of the amount which applied at intervals will cover the ground during the irrigation season to the depth required for successful agriculture, namely, 1 acre-ft. to an acre or 2 acre-ft., or more.

In the discussion the fact was emphasized that beyond a certain minimum amount, the more water used, the smaller the crop return, and that the best crops were being raised with an amount of water which the average farmer considers as entirely insufficient. Thus it has resulted that in years of drought the crop returns have frequently been the largest and best, because the farmers could not obtain all the water which they thought was necessary to secure the best crops.

It is true that in some cases with grain there has been a slight increase in yield per acre by additional irrigation; but it was shown that this same amount of water applied to two acres or three acres would have produced two or three times as much grain, although at a slightly lessened rate per acre irrigated. In other words, the maximum efficiency of the water is usually when it is applied at a depth of less than 2 ft. per acre and decreases with added amounts. All such general statements, however, are subject, of course, to qualifications when they are applied to individual conditions as to soils, climate, etc.

The result of the conference was to make prominent the needs and opportunities of the canal riders, to clarify ideas concerning the necessity of rotation of delivery to the farms, of the need of accurate records of the amount delivered, and of the strengthening of the system of direct control by the central management of the water until it is actually measured in rotation to each and every farmer, beginning usually with the remote farm or last on the lateral, and taking each farm in turn, with such modifications as may be necessary to meet peculiarities of different soils or different crops.

The continuous flow was condemned as leading to swamping of the lands and to waste of the time and effort of the farmer as well. The mutual interchange of ideas in the discussion and in conversation between individuals was invaluable as bringing about a better conception of the duties of the canal manager and the strengthening of the determination to reach a higher degree of efficiency and economy in the maintenance and operation of the canals.

Impermeability Tests on Concrete

By James L. Davis*

The following tests were made by the author when he was in charge of the laboratory of the New York City Board of Water Supply, in connection with the design of the Catskill Aqueduct. The results were later incorporated in a thesis submitted to the University of Vermont in partial fulfillment of the requirements for a graduate degree of Civil Engineer. The present abstract takes up in order the effect upon the permeability of concrete of the inclusion of hydrated lime, puzzolana, clay, very fine cement and additional cement and in addition gives some new figures on the variation with the pressure of leakage through concrete.

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The use of hydrated lime as a means of rendering concrete structures impervious to water has received the attention of several investigators, whose experiments have generally shown favorable results from its use. Engineers have employed this material in waterproofing reservoirs and tanks and have secured watertight structures.

The tests described below were undertaken with a view to determining the merits of this material and also puzzolan cement made by grinding together a mixture of blast-furnace slag and lime. Two brands of hydrated lime were used, a high calcium and a magnesian lime, each being a high-grade representative of its class. A single brand of puzzolan cement was used.

The tests were based for ready comparison on plain concrete in proportions 1:3:6 by weight. A lean mix was adopted to insure measurable leakage of the blanks. The increasing proportions of cementing materials used are given in the tables as fractions of the basal proportions of cement in order to show in an elementary manner the scheme adopted. The aggregates used were ordinary quartz sand and gravel supplied from Long Island banks for the New York market. The sand all passed a sieve with 0.2-in. square openings. The gravel passed the 1.75 in. and was retained on the 0.2-in. sieve. The density as well as the strength and permeability of the various mixtures was investigated.

The density test is becoming one of the recognized means of determining the properties of mortar and concrete. The density of concrete is defined as the ratio of the sum of the volumes of the solid particles, cement, sand and stone in the mix to the total volume of set concrete. It is the complement of the air and water voids. The methods of determining density will not be given here. (See "The Laws of Proportioning Concrete," by William B. Fuller and Sanford E. Thompson, *Transactions* Am. Soc. C. E., Vol. LIX.)

The permeability test specimens were cylindrical, 8 in. in diameter and 6 in. in length. About two weeks before testing the specimens were chipped with chisel and hammer to remove the "skin" and were inclosed over the sides and one end by neat cement casings poured around and over the specimens which were centered in circular molds 12 in. in diameter. A pipe connection extended through the casing in line with the axis of the cylinder and terminated in a cushion of coarse, washed sand 1 in. in thickness, covering the end of the specimen. This sand cushion prevented the neat cement paste with which the casings were made from coating the end of the specimen and permitted the water to act over the full end area. The specimens being coupled to vertical outlets from the bottom of a pressure tank, the water was forced to traverse the entire thickness of the concrete and was caught and weighed as it dripped from the exposed ends. The leakage recorded is the total weight passing during the last 10-min. period of the 1-hr. test. Previous studies have shown that fairly uniform conditions of flow are established within the hour when testing under the pressures used, 40 and 80 lb. per sq.in. The strength specimens were cylindrical, 6 in. in diameter and 12 in. in length. The tests were made on a 100,000-lb. screw-power testing machine, the crushing tool being fitted with a spherical bearing. The specimens were cushioned top and bottom with two thicknesses of blotting paper.

In the tabulated results several minor inconsistencies appear. To maintain comparable conditions throughout a series of concrete tests is a difficult matter. Both permeability and strength tests are greatly affected by slight excesses or deficiencies in the amount of mixing water used. The required amount of water varies with the brand of cement and its degree of fineness, the fineness of the aggregate and other factors. Final determination of the proportion of water depends in some measure on the judgment of the operator. Under 40-lb. per sq.in. water-pressure portland cement concrete in proportions 1.2:3:6, or richer, and all proportions of hydrated lime used give impervious concrete. Puzzolan cement in proportions 1.3:3:6, or richer gives nearly impervious concrete.

At 80-lb. pressure several of the above described mixes are practically impervious, and none of them give much leakage.

High calcium lime is the only material giving entirely consistent results in decreasing permeability in proportion to the amount used. It is possible the richest proportions of magnesian lime and puzzolan cement were too dry for best results. (See tabulated percentages of water in Table I.) Averaging all comparable proportions the relative strengths at 3 mo. age are as follows:

Portland cement	Calcium lime	Magnesian lime	Puzzolan cement
100%	85%	76%	81%

The density tests show unexpectedly uniform results throughout the series. Hydrated lime alone yields about 2½ times the volume of paste that an equal weight of portland cement does. A record of the volumes of rammed concrete produced in the tests was kept as a check on the volume computed from the density tests.

Comparison of volumes as tabulated is based on the volume of the plain concrete as a unit. The lime does not have an appreciable effect in increasing the volume of concrete; neither does it increase the density. The result is an apparent paradox. Tests on the richest cement-lime paste used in comparison with cement paste showed the cement-lime mixture gave an increase in volume of paste of 29% over plain cement paste. The density of this paste was 0.42. It was, therefore, very porous and must have contained a large amount of free water. The density of the plain cement paste was 0.52.

Comparison of the relative volumes of solid particles in the two pastes resulting from equal weights of dry materials is made as follows:

Volume of cement-lime paste equals 129% of cement paste.

$1.00 \times 0.52 = 0.52$ = relative total volume of solid particles in cement paste.

$1.29 \times 0.42 = 0.54$ = relative total volume of solid particles in cement-lime paste.

The reason for the failure of the lime to produce measurably denser concrete thus becomes evident. The low density resulting offset the increased volume over cement paste. Comparison of the density computations not here given showed that a smaller volume of air was entrained in the concrete where lime was used. The failure of the lime to give an increased total volume of concrete was due to the replacement of free water and entrained air in the plain concrete by the porous water-filled cement-lime paste. This paste simply occupied space which in the

plain concrete was filled with water and air, and therefore no appreciable increase in gross volume resulted.

This latter result suggests that the use of this mixture of cement and lime should give superior water-resisting concrete by filling the larger interstices between the particles of aggregate with this paste. While this paste will not reduce the total percentage of voids in the mass, it will fill the comparatively large-sized pores—through which water can pass quite readily—with this fine pored substance, thus offering much resistance to flow.

The permeability tests here given bear out this deduction to some extent, particularly in the tests at 40 lb. pressure. The practical advantage does not, however, appear from these tests to be sufficient to merit much consideration.

With cement-lime paste, the maximum density any paste filled cavity can have is 0.42; with cement paste it may be 0.52.

Tests by other experimenters as well as other tests by the writer have shown the density of cement paste to average about 0.60 for pastes of ordinary consistency. Using this value the merits of this cement-lime paste compare less favorably than above.

Based on prices in New York markets, plain portland-cement concrete cost slightly less per cubic yard for materials than any of the other mixes containing equal proportions of cementing materials. For equal efficiency in waterproofing at 40 lb. pressure the use of hydrated lime reduced the cost of materials about 5c. per cu.yd. of concrete.

Puzzolan cement was at a disadvantage in this comparison on account of the remoteness of the mill from New York and the consequent high freight charge.

CONCLUSIONS—(1) Hydrated lime is effective in producing impervious concrete, but its use is doubtful economy, except, possibly, for resisting low pressure of water. Concrete in proportions 1:3:6 requires the addition of a proportion of lime equal to about 20% of the weight of the cement for efficiency against high pressure. This results in a slight loss in the compressive strength of the concrete as compared with the plain 1:3:6 mixture.

(2) It is probable it is not an economical material for structures subjected to tensile stress such as reinforced conduits.

(3) Except possibly for low pressures equally good results in impermeability can be obtained by the same cost invested in additional cement with resulting stronger concrete.

(4) The addition of lime increases the plasticity and mold-filling properties of concrete, resulting in smoother surfaces against forms. Its use may give practical advantages in filling around reinforcing steel and in other restricted spaces

TABLE I. PERMEABILITY AND STRENGTH TESTS OF CONCRETE. EFFECT OF HYDRATED LINE AND PUZZOLAN CEMENT.

Cement	Proportions by Weight	Leakage in grams Pres. 40 lb.	Leakage in grams Pres. 80 lb.	Comp. Strength 28 days	Lbs. per sq.in. 3 mos.	Comparative Yield, Volume	Density	Water %	Cost of Material per cu.yd.
Group A	1 : 3 : 6	6	47	745	1535	1.000	0.857	7.8	$3.513
Portland only	1.1 : 3 : 6	33	77	650	1180	1.035	0.812	8.4	3.512
	1.2 : 3 : 6	0	2	920	1860	1.045	0.788	8.3	3.608
	1.3 : 3 : 6	0	0	910	2000	1.069	0.805	8.5	3.633
	1.4 : 3 : 6	0	18	1070	1950	1.069	0.790	8.7	3.769
Group B	1.1 : 3 : 6	0	20	800	1615	1.032	0.816	8.0	3.563
Portland and high calcium lime	1.2 : 3 : 6	0	12	680	1320	1.038	0.804	8.7	3.679
	1.3 : 3 : 6	0	0	595	1330	1.069	0.793	9.3	3.704
Group C	1.1 : 3 : 6	0	4	475	830	1.038	0.789	9.1	3.553
Portland and magnesiam lime	1.2 : 3 : 6	0	0	765	1460	1.069	0.793	8.8	3.617
	1.3 : 3 : 6	0	14	760	1545	1.069	0.789	8.8	3.794
Group D	1 : 3 : 6	5	22	600	880	1.006	0.822	7.6	3.642
Puzzolan only	1.1 : 3 : 6	13	25	490	1415	1.017	0.833	8.0	3.747
	1.2 : 3 : 6	7	45	580	1345	1.030	0.798	7.8	3.841
	1.3 : 3 : 6	0	0	620	1305	1.028	0.784	7.9	3.974
	1.4 : 3 : 6	0	6	910	1505	1.075	0.817	7.7	3.949

The fractional parts in cement column of group A are excess portland cement; in group B, calcium lime; in group C, magnesiam lime and in group D, excess puzzolan cement.

Permeability specimens, cylinders 8-in. diameter, 6-in. in length. Tested at 40 lb. pressure per sq.in. for one hour, then at 80 lb. one hour without interruption. Three specimens in each average.

Portland cement; tensile strength, 1:3 Ottawa sand, 28 days 306 lb. per sq.in., sp.gr. 3.16. Thru No. 200-mesh sieve 80.5%.

Puzzolan cement; tensile strength, 1:3 quartz sand, 28 days 146 lb. per sq.in., sp.gr. 2.90, Thru No. 200 mesh sieve 95.8%.

Compressive specimens, cylinders 6-in. diameter, 12-in length, 28 day tests on one specimen usually. 3 months tests the average of 3 specimens in all cases. Permeability tests made at 28 days age.

Quoted prices in New York, per ton; Sand $1.08, gravel $1.40, portland cement $6.78, puzzolan cement $7.60, high calcium hydrated lime $8.00, magnesian hydrated lime $9.50.

(5) Puzzolan cement is slightly less efficient than the cement-hydrated lime construction. In this comparison the puzzolan cement is at an economic disadvantage because of the long freight haul.

CLAY IN CONCRETE

The object of the tests was to compare the effect of clay in reducing permeability with the effect of equivalent weights of extra cement.

The clay used was a white, pure clay from Georgia, intended to represent high-grade material in colloidal properties. Approximate quotations of prices, delivered in New York, gave the cost as very nearly equal to that of portland cement, weight for weight. The tests, therefore, afford a direct comparison of costs of the two processes of waterproofing, assuming that the use of clay involves no extra cost in mixing the concrete.

Plain concrete of two percentages of cement, 10% and 11%, were selected as the basis of the tests, the total percentages of fine material in the dry mix, 45%, remaining constant. The percentages of clay used were based on the weight of the sand and replaced the stated percentages directly by weight. The percentages of clay selected were 5, 7.5 and 10%. For comparison, a series of specimens was made in which extra cement replaced the stated percentages of sand in the same manner as the clay; also blanks or specimens containing no clay or extra cement.

The casings of neat cement in which the specimens were inclosed for testing were not as perfect as are usually secured, and permitted a small leakage between casing and specimen in a few instances. The water appeared at the edges of the specimens and could not be separated from that coming through the concrete. In tabulating the results these defective specimens, as determined by the judgment of the observer, were omitted.

Table II shows, as in previous tests with clay, a marked decrease in permeability over plain concrete, but as compared with the extra cement there is no practical advantage. Both processes give impervious concrete at 80 lb. pressure. It is of practical value to note that the concrete of ordinary sand and gravel con-

TABLE II. PERMEABILITY AND STRENGTH TESTS OF CONCRETE. EFFECT OF CLAY.

	Proportions by Weight Cement	Clay	Sand	Gravel	Clay per cent	Leakage in grams Pres. 40 lb.	Leakage in grams Pres. 80 lb.	Comp. Strength lb. per sq.in.	Density	Water %
Group A	1	0	3.50	5.50	0	6	73	770	0.789	9.3
	1	0.18	3.32	5.50	5	0	3	910	0.782	8.1
	1	0.26	3.24	5.50	7.5	¼	9	1110	0.768	9.6
	1	0.35	3.15	5.50	10	0	0	945	0.770	9.2
Group B	1.18	0	3.32	5.50		0	2	1130	0.807	7.9
	1.26	0	3.24	5.50		3	10	1290	0.100	8.3
	1.35	0	3.15	5.50		0	0	1265	0.780	9.2
Group C	1.1	0	3.40	5.50	0	37	128	800	0.775	9.7
	1.1	0.17	3.23	5.50	5	0	0	880	0.780	9.3
	1.1	0.26	3.14	5.50	7.5	0	0	905	0.772	9.3
	1.1	0.34	3.06	5.50	10	0	Trace	905	0.777	9.8
Group D	1.26	0	3.24	5.50		3	10	1290	0.800	8.3
	1.35	0	3.15	5.50		0	0	1265	0.780	9.2
	1.44	0	3.06	5.50		Trace	17	1395	0.791	10.4

Sand, Cow Bay passing 0.2 in. sieve. Gravel, Cow Bay between 1.75 and 0.2 in. sieves.

Portland Cement; tensile strength, 1:3 Ottawa sand, 28 days, 329 lb. per sq.in. sp.gr. 3.18, Thru No. 200 mesh sieve 76%.

White Georgia clay passing No. 30 sieve.

Compare group A with B, C with D, Groups A and B based on 10% of cement, Groups C and D on 11% of cement. Clay replaces stated percentages of sand based on the blank. Age at testing 28 days. Duration of permeability test one hour at each pressure. Leakage reported for last 10 min. Three specimens in each average usually. Specimens Cylinders 8 in. in diameter, 6 in. in length. Compressive specimens Cylinders 6 in. in diameter, 12 in. in length. One specimen in each test.

TABLE III. PERMEABILITY TESTS OF MORTAR, EFFECT OF VERY FINE CEMENT.

Brand No.	Leakage in grams: Normal Cement Pres. 40 lb.	Leakage in grams: Cement Pres. 80 lb.	Leakage in grams: Sifted Cement Pres. 40 lb.	Leakage in grams: Sifted Cement Pres. 80 lb.	Fineness: Sieve 100	Fineness: Number 200	Specific gravity: Normal	Specific gravity: Sifted
1	3	22	3	33	96.5	79.8	2.16	3.13
2		25		2	93.5	74.6	3.17	3.13
3		29		Trace	97.6	89.2	3.08	3.05
4		331		81	94.7	84.9	3.16	3.14
5		27		Trace	92.3	78.9	3.13	3.12
6		31		2	91.3	79.4	3.14	3.11
7		5		0	95.4	75.0	3.19	3.17
8		6		Trace	95.3	81.0	3.18	3.16
9		71		0	91.0	73.0	3.10	3.09

1 Retained on No. 200 sieve, 2163 grams leakage at 40 lb. pressure.

Proportions 1:4 by weight. Sand Cow Bay graded so as to be permeable.
Age 28 days. Duration of test one hour. Leakage reported for last 10 min.
Specimens 2 in. cubes inclosed in neat cement casings.
Five or six specimens in each average except for brand No. 7, in which three specimens were used. Temperature of water 63° to 68° F.

taining 13.5% cement was impervious at a pressure corresponding to 185 ft. head of water.

There is a trivial discrepancy, 0.01%, in the percentages of excess cement in two of the tests in group D as compared with the percentages of clay in the corresponding tests in group C. It will be observed these tests in group D were brought down from group B, these specimens containing so nearly the right percentages of cement that new tests were not required for comparison with group C.

DENSITY—The clay slightly decreased the density in the 10% concrete, and slightly increased it in the 11% concrete. The excess cement slightly increased the density in both the 10 and 11% concrete, with exception of the 10% increase in the 10% concrete. The maximum increase with both the 10 and 11% concrete was with 5% excess cement.

STRENGTH—Strength was tested only incidentally, the material used for the density tests being utilized to produce a single 6x12-in. compression cylinder of each mix for testing at 28 days' age. The clay gives increased strength over the blanks, but a smaller increase in all cases than the corresponding excess of cement.

It is noticeable that the clay gives better results in the leaner concrete. This seems to indicate that the clay acts simply in a manner similar to ordinary very fine aggregate, for it is well known that lean concretes are benefitted in strength by the addition of fine material, such as loam and dust, while rich concretes are not.

NOTES ON CLAY—It should be remembered that these comparisons are based on the assumption that no extra cost in mixing the concrete is involved in the use of the clay. This assumption is undoubtedly in favor of the clay, as special appliances for introducing it would be necessary. In these tests the clay, which was in a comparatively dry and lumpy condition, was pulverized and sifted to pass a No. 30 sieve. Fifty-four per cent. passed the No. 100, and 15% the No. 200 sieve. Should it be found necessary to adopt this method in practice, the process would involve considerable expense. A less expensive method, if found practicable, would be to add the clay to the mixing water.

Should it be found that common brick clay would serve the purpose, this material could be obtained for about $3 per ton, or about three-eighths the cost of cement. This advantage would be partially offset by the mechanically combined water in the clay. Clay as taken from the bank ordinarily contains 20 to 40% of mechanically combined water. This amount can be greatly reduced by air drying, but clay is very hygroscopic and may absorb as much as 10% of its weight of water from the atmosphere.

CONCLUSIONS—(1) Clay added to ordinary concrete gives beneficial results in permeability and strength, with no practical effect in density.

(2) Compared with an equal excess of cement by weight, clay gives no advantage of practical importance in permeability or density, and results in a loss in strength.

(3) Both processes give impermeable concrete under 80 lb. pressure.

(4) If the use of clay is practicable on a working scale, its possible economic use under two methods is evident:

(a) By mixing with the cement at the cement mill. The mixed material would have to be sold about 20% cheaper than ordinary cement.

(b) By mixing in the field in localities where the cost of cement is high and clay can be obtained very cheaply.

Subsequently to the above tests another series was made in which blue New York brick clay was substituted for the white Georgia clay. The results confirm the earlier tests.

EFFECT OF VERY FINE CEMENT

Tests on mortar specimens were made using cement in its normal condition, parallel tests being made using portions of the same samples of cement sifted through the No. 200 sieve. A single test was made using the residue on the sieve. Nine well known brands comprised the series.

The marked decrease in permeability, as shown by the accompanying Table III, resulting from the sifted cement shows that as in strength so in permeability, the finer particles only are efficient. Extremely fine grinding may be of even more importance for its effect on impermeability than on strength.

ADDED CEMENT AS A FILLER

The writer designates such finely divided materials as hydrated lime, clay, puzzolan cement, sand cement and very fine sand, for want of a more scientific name, as pore fillers. The preceding and other tests not described here have demonstrated that such substances may be used to produce highly impermeable concrete. The same result can, however, be obtained by the use of an extra amount of portland cement, at less cost usually than by any of the special materials, and in all cases with an increase in the strength of the concrete over the other materials. For impermeable construction concrete should contain not less than 45% of combined fine aggregate and cement. With ordinary aggregates 15 to 18% of the entire dry mixture should be cement unless the resisting walls are several feet in thickness.

In all the preceding tests the smooth top and bottom surfaces of the specimens were chipped off. The surface formed against smooth forms is very highly effective against permeability if unbroken. Offsetting this important matter in practical work we have the usual necessity of depositing the concrete in successive layers with the possible attendant formation of planes of stratification parallel to the water pressure. Leakage in this direction, unless the concrete is of such a wet mixture and the construction so continuous as to prevent the formation of such planes, may be many times greater than that due to perpendicular pressure. In one test on 1:2.7:6.3 concrete the excess of leakage parallel to the bedding planes was 70%.

VARIATION OF LEAKAGE WITH PRESSURE

In this series the aggregates included quartz gravel, crushed limestone, gneiss and shale.

TABLE IV. PERMEABILITY TESTS OF CONCRETE, VARIATION OF LEAKAGE WITH PRESSURE

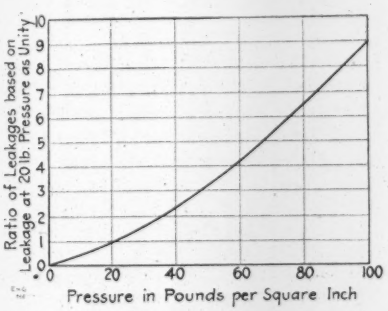
Sand	Stone	Proportions by Weight	Pressure and Leakage: 20	40	60	80	100	Ratio of Leakages: 40-20	60-20	80-20	100-20
Cow Bay	Limestone 1.75-0.2 in.	1:3.50:5.83	3	6	13	23		2.00	4.33	7.67	
Cow Bay	Gneiss 1.50-1.0 in.	1:3.50:5.66	5	19	35	47		3.8	7.00	9.40	
Cow Bay	Gneiss 1.50-0.2 in.	1:3.50:5.66	29	64	109	157	205	2.21	3.76	5.42	7.07
Crished Gneiss	Gneiss 1.50-0.2 in.	1:3.60:5.66	55	126	220	361	496	2.29	4.00	6.57	9.02
Cow Bay	Gravel 1.75-0.2 in.	1:3.50:5.50	14	27	51	80	132	1.93	3.64	5.72	9.44
Shale and Cow Bay	Shale 1.75-0.2 in.	1:3.53:5.72	14	22	48	80		1.59	3.43	5.71	
Average								2.30	4.36	6.75	8.51

Specimens cylinders 8 in. diameter, 6 in. length.
Age at testing 28 days.
Cement portland, 81% passing No. 200 sieve.
All sand passed a 0.2 in. sieve.
Pressures in pounds per square inch.

The fine aggregates included both natural silicious sand and screenings from the coarse aggregates. In one set a half and a half mixture of natural sand and screenings was used.

The series, therefore, represents a wide range in materials. Each of the six sets consisted of three specimens. Nearly every specimen was tested at each of the five pressures. The specimens constituted the blanks from a larger series of permeability tests made at 40 and 80 lb. pressure in which certain chemicals were investigated for their waterproofing properties. It is unnecessary to describe the larger series here. The present tests were made by subjecting the specimens to a second series of pressures of greater range than the original pressures. Following the first tests the specimens were allowed to drain about 2 hr. Pressure of 20 lb. was then applied and raised to 40, 60, 80 and 100 lb. at 30-min. intervals. The total leakage for the last 10 min. of each period is used in this study.

Observations early in the tests showed that for this series fairly uniform rates of leakage were established within 30 min. after pressure was applied.



VARIATION OF LEAKAGE THROUGH CONCRETE WITH PRESSURE

The average results on each set of three specimens are given in Table IV and averages for the entire series by the accompanying curve.

The range in pressure was sufficient to cover all heads up to 230 ft. The general conclusion is reached that leakage increases more rapidly than pressure. In any practical case, having the leakage determined by a test within the range of pressures given above, the leakage at any other pressure may be estimated by referring to the curve.

Lean concrete was used in order to insure measurable rates of leakage throughout the series.

The leakage was higher in this series of tests than in the original tests on the same specimens. The average increase for the eighteen specimens was 29% at 40 lb. and 12% at 80 lb. pressure. This indicates that raising the pressure enlarges the water passages. It is probable that under continued action the rate of leakage would decrease in the usual manner.

American Rolling-Mill Practice*

BY J. PUPPE†

The development of the iron industry of North America, which has achieved as remarkable a record of progress in the last decade as in the preceding one, and the improved methods of working, especially in respect of rolling-mill practice, still form an object lesson of paramount interest to European iron manufacturers. Early in 1911 it was the author's privilege, in company with Mr. Maleyka, Chief Engineer of the Siemens-Schuckert works, and Mr. Werner F. von Siemens, to visit the majority of those iron works of the United States where typical American rolling-mill practice is followed, for the purpose of studying the latest methods and improvements. Among the plants visited may be mentioned: (1) the Lackawanna Steel Co. works at Buffalo; (2) the several works of the Carnegie Steel Co. at Duquesne and Homestead, the Edgar Thomson works at Braddock, and the Ohio works at Youngstown; (3) the Jones & Laughlin Steel Co. works; (4) the National Tube Co. works at McKeesport and Ellwood; (5) the Bethlehem Steel Co.; (6) the Indiana Steel Co. works at Gary; (7) the Illinois Steel Co. works; (8) several works of the American Steel & Wire Co.; (9) the American Sheet & Tinplate Co. works at Vandergrift; (10) the Youngstown Sheet & Tube Co. works.

COGGING MILLS

During the 'nineties, cogging mills in the United States were almost exclusively constructed on the three-high system, but since the introduction of the 4-in. billet the two-high reversing mill has been practically universally adopted. The three-high mill was brought to a remarkable state of perfection by the brothers John and George Fritz, and there are still a number of such mills at work, especially where one section only, or at all events a very limited number of sections, is rolled continuously. In rolling 4-in. billets, however, the great length of the pieces made it impracticable to use the three-high mill, as the lifting tables could not be made sufficiently long to accommodate them, and the two-high reversing mill had to take its place.

In contradistinction to German practice, where the cogging mill forms the link between the steel works and the mills for all sections down to 4 in. square and less and also for slabs and flats, in the United States it forms an integral part of a particular rolling-mill train, and performs the roughing down to a certain section only. Typical instances of this practice may be seen at Lackawanna and at Gary. At the Lackawanna works the cogging rolls serve for roughing down the ingots for the billet mill, whereas the heavy-rail mill has several stands of cogging rolls for that mill alone. At Gary, where the cogging rolls for the rail and billet mills consist of separate two-high sets followed by a three-high set, the arrangement has been planned not only with the object of getting the largest possible output, but has also been determined by the method chosen for driving the trains. In very rare instances, the cogging mill supplies the plate mill with slabs, the practice at the works of the Youngstown Sheet & Tube Co., affording one such example.

In all other mills visited, where slabs are rolled, a type of rolling mill entirely unknown to the author has been developed, namely, the slabbing mill, which may be described as a universal slab and roughing mill. The cogging rolls are generally of quite small diameter, the pitch circle of the pinions measuring as a rule 35 to 40 or 42 in., the roll diameter being about 3 to 5 in. smaller. Latterly a 34-in. diameter has become the standard for such mills. On this account, the roll length is much shorter than in Europe, generally not exceeding 6 ft. 6 in., as compared with 9 ft. 4 in. in German mills. The arrangement of grooves is also different, the first groove not being at the side but in the center, and consisting really of the smooth surface of the roll, which is kept at its full diameter at that part.

The production of sections varying greatly in size is attained by giving a very high adjustment, in some cases three times as great as in European practice, where 40 in. is about the maximum. The same pressure can be applied to the rolls, while owing to the small diameter less power is required for driving. The wobbler connecting the upper roll with the pinion must be of a length corresponding to the increased height of rise, and in some instances it was found to measure 22 ft., and in another 17 ft., long.

With such mills remarkably high outputs can be obtained. For instance, the cogging mill at Lackawanna turns out 500 tons in a single shift, the 40-in. mill at Duquesne averages 600 tons per shift, and the 38-in. mill at the same works can turn out 1300 tons per shift. These quantities, of course, fluctuate considerably, but the facility with which such large outputs are obtained is explained by the fact that the ingots are not rolled to anything like the same length as in Europe, the elongation being generally five to six times, and at most seven times. The rolling period is consequently much shorter. On timing the operations at random, the author noted that nine passes were made in 40 sec. and again in 47, seven passes in 41 to 48 sec. On other occasions the times were remarkably

*From a paper before the Iron and Steel Institute of Great Britain, Oct. 1, 1912.

†Breslau, Germany.

short. In the matter of rapid passes, the three-high mills show great superiority, as might be expected.

Another striking difference between German and American practice is the rate of diminution of the draft of cogging rolls. In Germany, a reduction of 14% is hardly ever exceeded, and with harder material an average of 11 to 12% reduction is the rule; the reduction in the draft from one groove to the next often amounts to 20% in American practice. The roughing rolls of the rail mill at Lackawanna even give an average reduction of 24% per pass in the first six passes. How far the structure and quality of the material suffer in the case of rails is a question which will be discussed further on. The final section of the piece after passing the cogging rolls is of course larger than in German practice, and varies generally from 6 to 8 in. square.

The shortness of the rolling period is further accounted for by the manner of controlling the auxiliary engines, which now very generally consist of electric motors. The controllers are operated with very short levers with short ranges, and there are only three notches, "Stop," "Forward," "Backward," with no intermediate steps.

The rolling-down operation is mostly performed in the same way as in Germany, the piece being continually turned over and the section retaining its square form. Here and there, however, an entirely different practice is followed. For instance, in the 35-in. mill of the National Tube Co., the ingot is rolled out flat in nine passes through the widest groove to a thickness of 4 in. It is then turned on edge and put through the 4-in. groove, then two passes are again made through the 12-in., one pass through the 5-in., and finally one through the 7-in. groove. On account of its great width, after the first nine passes it requires to be guided into the next groove and held with hydraulically operated guides. This method has been introduced at one mill in Germany, but it has considerable disadvantages—(1), the difficulty of putting the wide piece through the rolls on edge; (2), the tendency to crack at the corners, owing to the material being subjected to the roll pressure for so long in one direction.

Summarizing all these facts, it appears that American cogging mills differ considerably from German ones both in point of construction and design and also in the method of working, but that the high rate of production is chiefly rendered possible by the very much simpler plan of rolling to larger sections, and by the rapid and accurate handling of the auxiliary engines.

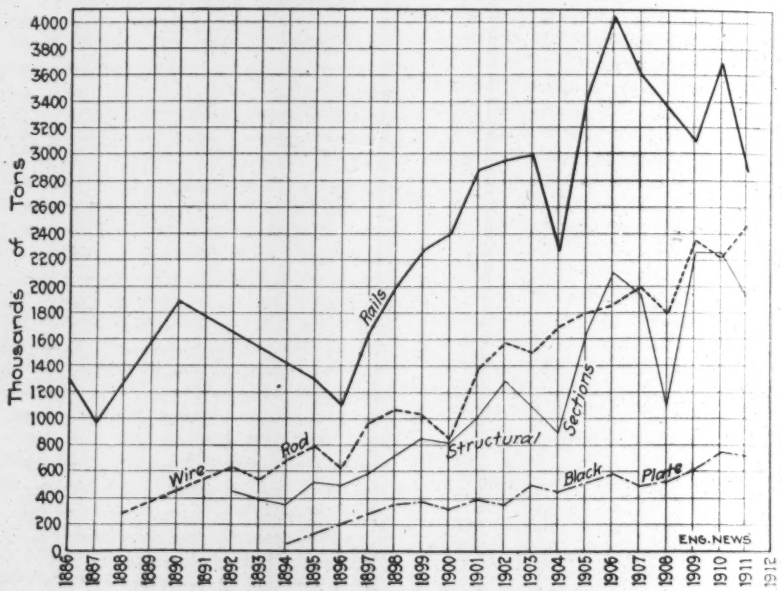
The ingots are almost always heated in soaking pits which can take several ingots at one time. This is usually partly on account of the cheapness of fuel, and partly because the service of the mills being almost entirely automatic the ingots must be of a uniform temperature throughout.

Billet Mills

In proportion to the lightness of the finished product, is the difficulty of preparing pieces of a suitable initial section. The use of a section rolled from a large ingot, as represented by the billet, dates in America from the year 1880. At first, billets with a section of 4x4 in. were produced in the roughing rolls, and this practice led to the abandonment of three-high mills in favor of the two-high reversing type, on account of the unsuitability of the lifting tables for dealing with pieces of great length. Later the practice was further developed by the rolling of billets of a still smaller section, partly with a view of relieving the roughing rolls and partly for the purpose of lightening the work of the finishing rolls; also it was an advantage to roll down to as small a section as possible before reheating the billet, which in any case was necessary before sending it to the finishing mill. The economy of having a set of rolls intermediate between the roughing rolls and finishing mill is apparent where there is a large market as in America, provided it is technically possible to construct a mill capable of taking the whole production of the roughing rolls and rolling it down in the same heat. It would be economically possible to roll 4-in. billets in the roughing rolls, but since these are designed for definite sections of large size their whole object would be lost if it were attempted to roll billets of any size under 4 in. square.

It is noteworthy that, at first, the endeavor was to roll from as large a section as possible direct down to the finished shape in one heat, and the introduction of the 4-in. billet marked a great advance, as compared with the 1½-in. billet, in the production of which two heats were required. Latterly the tendency is to revert to the billet of small section, the weight being kept up by making them very long. The Morgan mills, which work up 1½-in. billets, 30 ft. long, are now in great favor.

The semi-products of the roughing rolls, however, generally average about 6 to 8 in. square, and, for the production of small profiles and wire rods, these are rolled down into billets varying from 4 to 1½ in. square, for which and also for flat bars, continuous billet and bar



Output of American Rolling Mills

mills of eight to ten stands are almost always provided. Where the output is too small to make it worth while to install a billet mill, the ingot is rolled down further in the roughing rolls—as in the two-high reversing mill of the Tack Co. at Grand Crossing, where 1¾-in. square billets are rolled in the roughing rolls. However, to expedite the work, the piece after being reduced to 4 in. square is sent back over the roll without reversing, the engine meantime running away.

The only noncontinuous billet mill is the three-high stand with 23-in. rolls of the American Steel & Wire Co. at Newburgh, which rolls down pieces of 7x8 in. into 4-in. billets in seven passes. Also the billet and bar mills of the Carnegie Steel Co. at Duquesne and the Ohio works are not continuous mills in the usual sense, but are converted rail mills, which, however, are very suitable for the production of large semi-products. A set of continuous rolls has been added in

which billets of the smallest section can be rolled.

The billet and bar mill at Duquesne takes the material coming from the 38-in. two-high mill in front and from the 28-in. three-high mill, and rolls it down simultaneously into bars and billets or into fishplates and billets, the method being as follows: The first piece, after one pass through the 21-in. three-high billet mill, is cut straight into thickish billets. The second piece, after one pass in the first stand, is also cut into billets, which each receive one pass in the second stand and are then taken direct to the continuous mill where they are rolled down into thin billets. The third piece is also cut up after one pass through the first stand, the resulting billets being then each passed once through the five following stands, and finished into fishplates or bars.

The converted rail mill at Ohio is also very suitable for rolling billets, since its construction as a double two-high reversing mill gives it great adaptability to cope with the large output of the 43-in. three-high roughing rolls. The production of this whole mill amounts to 3500 tons per 24 hr. The appliance for pushing the billets sideways is ingenious. The pusher works very rapidly, and in returning is lifted clear so as to allow the next billet to run under it.

The roll diameter in the continuous mills is comparatively small, being seldom above 18 in. and in some mills not more than 14 in. Considerably less power is required, but this is more than compensated for by the losses in the trains of gearing. The small diameter entails a short length of roll, with only few grooves, which makes possible the use of very high pressures with safety. The average reduction of draft in continuous mills is always above 20%, whereas the average reduction in the 23-in. three-high mill of the American Steel & Wire Co. is only about 16%. The drafting is usually designed with the aim of reducing to a minimum or avoiding altogether the turning and up-siding of the piece between two stands.

The drafting for rolling bars is almost always designed to avoid up-siding. All the grooves are flat, and by the selection of a correct initial section the desired width is obtained in the final closed pass, sometimes also by the use of vertical rolls behind the last stand. The two last passes of the bars are in such cases made through smooth rolls. The output of the continuous billet and bar mills corresponds to that of the roughing mill in front. At Gary the production is 300 tons of 4-in. billets per hour and 150 tons of 1¾-in. billets. At Lackawanna the output is 70 to 80 tons per hour, but even that would be an unusual achievement in Germany. These results are obtained by driving the last stand at a comparatively high speed, 90 to 200 r.p.m., the first stand running at 9 to 12. On timing the speed of working, the author found that the time from the entering of the roughed-down ingot between the rolls of the first stand and the entering of it at the last stand was half a minute and the rolling time of a whole ingot of 2½ tons and 7x7 in. was 2½ min. At the billet mill of the Ohio works the piece went through from the first to the last stand in 28 sec., the last pair of rolls being 15 in. diameter, and running at a speed of 200 r.p.m.

The smallest billet section is 1½ in., and 8 in. is the uniform width for bars.

It is the almost invariable practice to cut both billets and bars with an electrically operated flying shears. They are cut into pieces of definite length, and conveyed away at once by the live rollers behind the shears. The cooling proceeds in much the same way as here. At the American Sheet & Tinplate Co.'s works, however, a cooling drum is installed, measuring 95 ft. long and 8 ft. 6 in. diameter. This apparatus revolves very slowly and lifts the bars from the roller table of the shears and deposits them on the hot bed roller table, the bars cooling down all the time that they are being slowly carried round on the drum.

Rail Mills

The rapid growth of population in the United States was accompanied by an enormous development of railway enterprise, and for some years from 1865 onward the supply could with difficulty keep pace with the demand. In 1878 there were 11 works at which rails were rolled, the yearly output being 34,000 tons. In 1880 the number of works was the same, but the production had increased to 800,000 tons. At the present time, 32 years later, there are 14 rail-rolling mills, with a yearly output of about 3,000,000 tons. As the rate of production increased the cost naturally diminished, the greatest economy being due to labor saving. The cost of labor per ton fell from about $3.20 at the end of the eighties to $1.65 in recent years, wages remaining at nearly the same figure.

It is of interest to study the question of rails in connection with the increase in production. When a single rail mill, such as that at the Edgar Thomson works, or at Gary, turns out from 3500 to 4000 tons in 24 hr., it is a question whether that amount of care is bestowed on the work which is desirable in view of the great importance of obtaining the requisite high quality in the finished rails. This supposition would seem to some extent to be confirmed by the fact that rail breakages in American railways are of much more frequent occurrence than in Europe, notwithstanding that for a long time past various commissions of rail manufacturers and consumers have been investigating the causes of this trouble, and have endeavored by various means to improve the quality.

It must be admitted that the conditions of railway service in the United States are far more severe than with us, and that the loads and speeds have been very much increased since the 'eighties. The carrying capacity of the railways has increased five times and the speeds have been nearly doubled, while the weight of rail has not been increased in proportion. The load of freight cars has risen from 10 to 50 tons, and the weight conveyed by a freight train has gone up from 500 to 600 tons to 3000 to 4000 tons. The axle-load of freight locomotives is now 25 tons as compared with 11.5 tons formerly. Speeds of 75 miles per hour have to be maintained daily between stops in order to make an average speed of 50 miles per hour. From these considerations it will be seen that the risk of breakages must have increased considerably, especially in view of the low temperatures sometimes prevailing during the winter months.

Proposals for the improvement of the structure of the metal by lowering the temperature at which the rails were finished and a specified permissible maximum contraction, have not proved a sufficient remedy in increasing the resistance to shock and jarring. In 1903, the Rail Commission of the American Society of Civil Engineers received a pronouncement from a railway engineer-in-chief as follows: "The combining of the rail-rolling mills has resulted in a continuous deterioration of the rail material, and

TABLE I. PRODUCTION OF AMERICAN STEEL RAILS

Production of Rails.	1907 Tons	1908 Tons	1909 Tons	1910 Tons	1911 Tons
Acid, bessemer steel rails: Total	3,354,841	1,375,903	1,835,527	1,948,586	1,070,275
Including titanium-steel rails	.....	.....	37,398	177,619	117,297
Open-hearth rails: Total	256,747	576,381	1,276,056	1,743,353	1,703,754
Including titanium-steel rails	.....	.....	13,915	26,212	38,141
Special steel rails: Total	.....	.....	51,313	203,331	156,453
Including titanium-steel rails	.....	.....	36,520	198,535 ferro-titanium 541	155,438
Including manganese-steel rails	.....	.....	12,484	396	1,015
Including nickel-steel rails	.....	.....	including chr. va. 1,265	82	.....
Including electro-steel rails	.....	.....	.....	4,277	462
Total	3,611,588	1,952,284	3,111,583	3,691,939	2,867,954

Note.—The data of the American Iron and Steel Association (Iron Age, 1912, p. 673) differ considerably from those given by J. M. Swank in his report. ("Stahl und Eisen," 1912, p. 1285.) In another place it is stated in the statistics that of the 92,447 tons of rails (entered as electro steel, wrought iron, and re-rolled steel) 91,751 tons represent rerolled rails or rails renewed out of old steel rails.

every effort must be made to counteract this tendency."

Lately a thorough inspection has been maintained at the rail mills by the authorities of fifteen railway systems, with upward of 90,000 miles of track; throughout the day and night shifts the work in the steel works, at the roughing mills, the rail mills, and testing machines is supervised by an engineer in each department.

The question as to whether the number of rail breakages are due to inferior quality resulting from the rapid production on a large scale, in conjunction with the acid-bessemer process which has long held the field, or are to be attributed to the severe conditions of service, is a question which at all events is not yet solved. The fact is noteworthy, however, that the production of rails of special steel is now continually on the increase in the United States, and there has of late been a considerable decline in the output of acid-bessemer rails. In 1911, the production of bessemer rails was only 1,156,852 tons as compared with 1,948,586 tons in 1910, or a reduction of 40%[1]. On the other hand, the production of openhearth rails in 1909 was 121% greater than in the preceding year (in 1909, 1,276,056 tons, and in 1908, 576,381 tons). In the same manner the production of special steel rails rose from 51,313 tons to 203,831 tons, or about 300% between 1909 and 1910, and the production of titanium-steel rails increased from 36,250 to 198,535 tons, or by 440% (see table). During 1908-1911, that is, three years after the first trials with titanium-steel rails, 400,000 tons of such rails altogether have been laid at different times; the rails were rolled at the Lackawanna Steel Co.'s works, which make a speciality of them.

It is also noteworthy that at the Indiana Steel Co.'s works at Gary, openhearth furnaces alone have been decided upon, from which it is clear that American railway engineers prefer openhearth to acid-bessemer steel rails. At the same time the increase in the production of openhearth rails is also in some respects due to the increasing scarcity of suitable ores for smelting bessemer pig.

Naturally, the treatment during rolling has a particularly important influence on the rail quality. The initial and final temperatures, the cross-section and length of ingot, the proportion of initial and final section to the number of passes, the roll-drafting and the treatment of the finished rails, all play an important part. One would suppose that in the course of years a certain standard might have been adopted which would form a basis of comparison, and would permit conclusions to be drawn as to the quality of the finished product.

The temperature would, of course, be the first subject of observation. In 1901 the Kennedy-Morrison process of rolling was in use at the Edgar Thomson works, which, by means of a special hot-bed, enabled the temperature of the rails to be lowered before the last pass.[2] This would probably have but a slight effect in altering the structure or increasing the resistance to wear, considering that, in the very short time allowed, the cooling effect would not have penetrated uniformly to the internal metal of the rail. Moreover, the pressure in the last pass cannot be permitted in sufficient amount to influence the alteration of the structure throughout the whole section.

In the author's opinion a better solution of the question is to be found by paying regard to the number of passes and drafting, and giving attention to the temperature and pressures throughout the whole rolling operation. The shape itself and the distribution of the material have an important bearing on the cooling conditions.

The whole rolling operation, at least as far as regards temperature, might be better controlled if the specification required that the rail, after the final pass, should have a temperature corresponding to a definite longitudinal contraction, namely, for a 30-ft. rail of 100 lb. per yd., a contraction should be allowed of 6½ in., and $\frac{1}{16}$ in. less for each 5-lb. reduction of weight. Such rules would, however, only have some value if other points in connection with the construction of the rolling mill itself were taken into consideration. But the conditions of rail rolling in the various American rolling mills differ so much, especially as regards the points which influence the final temperature—such as initial and final section, number of passes, and the relation of these to one another, that even an approximate basis of comparison is impossible, and consequently any such rules would be absolutely useless.

In illustration of some great divergencies in rail-rolling practice at American rolling mills, some data have previously been published[3] relating to the ratio of the initial and final section to the number of passes, which permit a comparison with German rail-rolling practice. The figures are taken from reports of a commission of rail manufacturers and railway engineers, but the most important data concerning temperature and rolling period were never included, whereas a number of other particulars concerning shrinkage and amount of discard seem to the author to be of little value. To standardize the amount of discard is beside the mark, not only on account of the many conditions which influence segregation, but because every ingot requires individual treatment according to the depth of the pipe, which must at all costs be cut out. If the conditions of manufacture permit that the price may be increased according to the percentage of discard, this may have the effect of a premium for the steelworks which took no interest in the improvement of its ingots or in the reduction of pipe. In German practice the elimination of piping is practicable, and can be perfectly performed; the end surfaces are milled, thus allowing any defects to become visible. Such defects are not revealed by an ordinary saw-cut alone, as practiced in the United States.

It is clear, however, that it cannot be immaterial whether a comparatively hard material is rolled down to its final shape in 30 passes, with a reduction of 12% in section at each pass, or in 15 passes with a 23% reduction. The finishing temperature is bound to be enormously influenced by the number of passes and the reduction of draught, thus proving the usefulness of taking the contraction as a guide for the finishing temperature; moreover, the structure of the steel, especially at the lower temperature required in the case of the harder kinds, suffers through the too severe squeezing of the metal.

The comparative figures given in Table II for American and German rail-rolling mills show a much greater uniformity in favor of the latter, which entirely confirms the foregoing considerations. The German figures besides show a smaller average reduction of draught for the roughing passes and all the succeeding passes.

The nine rolling mills studied show in their construction and arrangement that the requirements for a high production are fulfilled by dividing up the whole mill into a series of subsidiary trains, each of which is independently driven. This subdivision led to the wide adoption of three-high stands, which developed further into non-reversing two-high stands in which one pass only is made. In this connection appears also the contrast with German and English conditions, where the reversible two-high mill is still preferred, and of necessity, because the mills are not built with the sole object of rolling rails, but have to deal with a much wider range of material, and the capacity reached by subdividing the mills could not be fully utilized under the market conditions of Germany and England.

The disadvantages experienced in a large plant built for making a special class of material, in not being able to utilize their full capacity, may be realized from the fact that the Gary works in 1911 turned out 286,492 tons of rails, or 10% of the whole rail production of the United States, and in the previous year 443,000 tons, or 12%, were manufactured. But the capacity of the Gary works is about 1,200,000 tons yearly, so that in 1910 the output was 37%, and in

[1] "Stahl und Eisen," 1912, p. 673.

[2] See also "Stahl und Eisen," 1908, p. 221.

[3] "Stahl und Eisen," 1908, p. 743; "Iron Age," 1908, p. 855.

TABLE II. COMPARISON OF WORK IN STEEL ROLLING MILLS

Mill No.[1]	Weight of Rail	Average Reduction per Pass Roughing Rolls	Total Number of Passes	Total Average Reduction per Pass
United States	Kilogrammes	Per cent.		Per Cent.
I	39.7	24	15	22
3	39.7	20	19	19
6	39.7	..	..	..
7	39.7	21	18	20
8	39.7	19	18	20
9	39.7	19	16	22
A	36.3	..	30	13
B	36.3	..	27	14
C	38.5	..	18	19
F	38.5	..	29	13
G	38.5	..	18	19
H	36.3	..	15	23
I	40.8	..	24	15
J	34.0	..	26	15
L	38.5	..	24	16
M	27.2	..	22	18
Average		20	21	18
Germany	Kilogrammes	Per Cent.		Per Cent.
A	41.0	9	28	14
B	33.4	10	31	13
C	45.9	13	24	15
D	33.8	13	24	15
E	41.0	12	24	15
F	33.4	12	24	14
G	45.9	12	24	14
H	41.0	11	30	12
I	33.4	11	30	13
J	33.4	11	28	13
K	20.0	11	30	13
L	30.0	13	22	15
Average		12	27	14

[1]See also "Stahl und Eisen," 1908, p. 784.

1911 only 24%, of the total capacity. Assuming that 500 shifts were worked, the production per shift for 1910 was about 880 tons, and for 1911 about 570 tons, which, though large, is but a small proportion of the maximum capacity of 2000 tons, and might have been attained with much simpler appliances in an ordinary German rail mill.

The number of stands varies according to the whole layout of the rolling mills and to the initial section of the ingot, and as the number of passes made in one stand is reduced the length of roll and diameter diminish.

A simple subdivision of the mill into two or three three-high stands, or two three-high stands and a two-high behind one another, as commonly practiced in Germany, enables continuous rolling to be carried on to a certain extent, and makes an increase in output possible, provided that by exact automatic working, as at the rail mill No. I of the Edgar Thomson works, several pieces can be rolled simultaneously.

Concerning the rail mill of the Indiana works, it is scarcely necessary to describe this here, as it has already frequently been described elsewhere. With regard to the draught, however, it may be mentioned that the ingot section is 20x24 in., and it is rough rolled in nine passes to about 8x8 in., and finished off in nine more passes without reheating. The average reduction of draught in the first nine roughing passes is 21%, which must be regarded as very high; in German roughing mills 15 to 17 passes would be required for this work. It should be noted that the two first roughing stands only run at 6 r.p.m., and the third and fourth stands at 10 r.p.m. The shape of the grooves indicates the tendency to reach the finished profile as soon as possible, and the reductions of section are very considerable.

The rails are cut to length by several saws operated together, by means of which a sufficient degree of accuracy is reached without the necessity of milling. By the omission of milling a great economy is obtained. The only machining operations to be performed after rolling and cutting to length are the straightening and drilling of the rails. Presses are mostly used for straightening, and the roll-straightening machine is rarely seen, though in common use in Germany.

Letters to the Editor

More Concerning Earth Pressures Against Retaining Walls

Sir—Referring to your editorial on the failure of the concrete retaining wall at Kingshighway Viaduct, in St. Louis, in your issue of Sept. 26, and to the empirical formula there suggested for the design of retaining walls: It seems pertinent to point out that the rational design of retaining walls at the present time is not likely to be helped by the recommendation of another empirical formula for indiscriminate use. Empirical formulas in use in the past took little or no account of the character of the foundation on which the walls were built and their use has undoubtedly been responsible for a large part of the failures in such structures.

A much more helpful suggestion in the writer's opinion would have been to point out that such structures should be designed for the worst conditions of back fill that can possibly occur, and that each case should be made the subject of careful study and analysis. A reference to the excellent report of the Committee on Masonry of the American Railway Engineering and Maintenance of Way Association, published in Bulletin No. 108, February, 1909, would also seem to be worth while.

J. B. FRENCH.

50 Church St., New York,
Oct. 21, 1912.

A Long Span Combination Highway Bridge

Sir—Referring to the letter of G. E. Farnsworth, in your issue of Oct. 17, 1912, asking if any of your readers know of a longer span wooden truss than that which he mentions across the McKenzie River, in Oregon, of 240 ft., the writer begs to say that he has seen the bridge to which Mr. Farnsworth refers and has knowledge of a combination highway bridge with a clear span of 300 ft. The bridge is located at La Grange, Calif., across the Tuolumne River, and has been used for years as a gaging station by the United States Geological Survey. It is not a Howe truss, however, but is more after the pattern of the Pratt truss, having an inclined wooden upper chord and vertical posts of timber, while the lower chords and inclined web members are of metal.

E. M. CHANDLER.

Burbank, Wash.
Oct. 23, 1912.

Braking Distances of Automobiles in Emergency Stops

Sir—The letter of John V. Hazen, in ENGINEERING NEWS, Oct. 10, 1912, discussing "Automobile Speed and Highway Location," mentions the emergency stopping of cars traveling at various speeds. About six months ago the writer had a few tests of emergency stops made that may be of interest along this line.

The total weight of car and passengers was 4137 lb. The wheels had smooth-tread tires. The stops were all made with the emergency brake. The tests were run on a dry asphalt pavement and on a 2% down grade. The speedometer was tested for accuracy over a measured course.

The car running at the following speeds was stopped in the distances shown:

Speed, miles per hour	Stopped in feet
6	1.67
10	6.0
15	9.5
20	36.8
25	42.0
30	47.5

The sudden increase in stopping distance shown between 15 and 20 mi. per hr. is unaccounted for, unless due to

some characteristic of the automobile used. The wide difference was noticed at the time and these speeds re-run, with no material change in the result.

The distance in which the car was stopped at a speed of 20 mi. per hr. practically agrees with the example quoted by Mr. Hazen.

F. H. CUSHMAN.

Engineer's Office, Tacoma, Wash.,
Oct. 21, 1912.

Spiral Curve

Sir—The Antofogasta Ry. must be "pretty hot stuff" if it goes in for spirals on meter-gage track, as described in your issue of Sept. 5. No such luxuries are to be encountered in this part of the world.

By the way, I have seen tack-splitters sorely puzzled when spiralling a compound curve to find themselves ¼ in. or more off line in sighting from one point of spiral to the other. Searles should really have explained for the benefit of engineers of that kind that his method of putting in a spiral between curves is not theoretical and does not give strictly accurate results.

It may not have occurred to some that the method of backsighting from the P. S. C. on an offset from the tangent instead of on the P. S. T. is quite applicable to the Searles spiral as well as to others with which it is the custom. When the spiral is short, a backsight on the P. S. T. will often throw a long curve considerably off, while an offset from the tangent can be set as far back as desired.

A. F. NYE,

Res. Eng., Great Western of Brazil Ry.
Pernambuco, Brazil,
Sept. 29, 1912.

[Engineers of the excessively accurate type, who set spirals to a hair-line and cut the lead rails of turnouts to theoretical length (regardless of rail joints) are those who fail to realize that there are relative degrees of accuracy. A little experience usually suffices to show them that hair-splitting accuracy is not essential in all cases and may be simply a waste of time and energy. This does not mean that work may be done inaccurately, but that it should be done with the degree of accuracy suitable to the case. —ED.]

Paneling as a Decorative Feature in Concrete Bridges

Sir—In ENGINEERING NEWS, Sept. 5, 1912, p. 455, in an article descriptive of a railway bridge over Ogden Boulevard, Chicago, there appeared some editorial comment to the effect that a more effective ornamentation in concrete, and particularly in concrete bridges, might be secured by the use of panels instead of colored tiling. In support of this criticism I would bring to your attention the accompanying views of the bridge across Euclid Ave. at E. 118th St., Cleveland, O., recently completed for the New York, Chicago & St. Louis R.R. and the Cleveland Short Line Ry. Co.

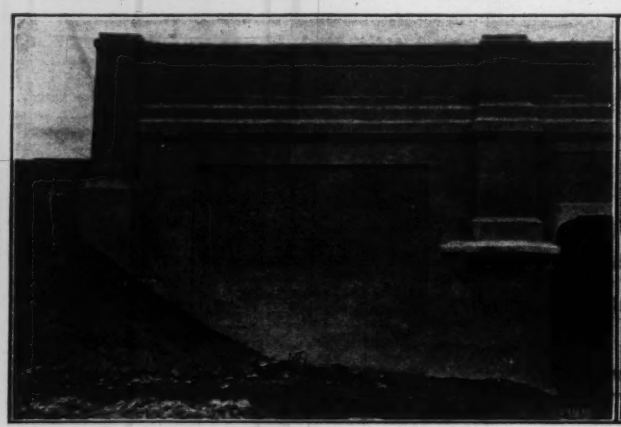


FIG. 1. AN ABUTMENT SHOWING CONCRETE SURFACE FINISH

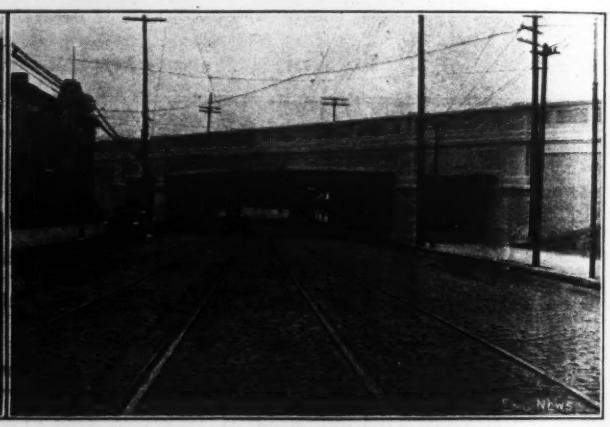


FIG. 2. THE EUCLID AVE. BRIDGE AT E. 118TH ST., CLEVELAND, O.

This is a four-track plate girder bridge, located on a curve, which required that the girders be placed 19 ft. 4 in. c. to c. and the span c. to c. of posts 90 ft. 4⅞ in. The use of these posts was necessary because a span from street line to street line would have exceeded the limit of plate-girder construction, and the citizens objected to the use of trusses. The floor of the bridge is composed of I-beams incased in concrete, and the track is ballasted with stone. The plate girders are entirely concealed with concrete fascia.

The noise from trains passing over the bridge is not sufficient to disturb an ordinary conversation on the sidewalk below.

ALBERT C. HIMES,
Engr., Grade Elimination,
N. Y., C. & St. L. R.R. Co.
Cleveland, Oct. 21, 1912.

The Argentine Railway Gages

Sir—In the footnote of an article discussing the gage of the Australian railways in your issue of Dec. 7, 1911, p. 674, the statement is made that "in countries of great area where recent choice has been possible wider gages have been adopted," and Argentine is cited as one of these.

The choice of a broad gage in Argentine was entirely accidental. At the time of the Crimean War some railway material which had been intended for India was diverted to the Crimea. When the first English line in Argentine was projected in 1855, about the time the Crimean War was ended, some of this second-hand material was bought and shipped to South America. This was of 5-ft. 6-in. gage, and so this gage became established for the English lines in Argentine.

The lengths of the lines of the three gages now in use are approximately:

5 ft. 6 in.	15,000 km.
4 ft. 8 in.	2,000 "
Meter	9,000 "

India is also referred to as one of the countries where recent choice has made possible the selection of a broad gage. I have no exact figures, but I believe the 5-ft. 6-in. gage is very old there, in any event in 1902 there were:

14,300 miles of 5 ft. 6 in. gage
10,900 miles of meter gage.

And although a decision to adopt the wide gage for future extension of trunk lines may have been made recently it must have been influenced by existing conditions.

F. LAVIS.

281 Reconquista,
Buenos Aires, Argentine.
Sept. 26, 1912.

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Engineering News

More Light on the Corrosion of Steel

An interesting and important contribution to the engineering profession's knowledge of the conditions affecting the corrosion of steel is given elsewhere in this issue in a paper by George C. Whipple, presented at the recent International Chemical Congress.

Mr. Whipple is well known as one of the most careful and thorough of engineering chemists. The investigations he describes were made for the City of Rochester, N. Y., to throw light, if possible, on the most durable material for use in laying a sewer outfall pipe nearly 9000 ft. long into Lake Ontario.

For several years past, those who are studying the corrosion of iron and steel have had their attention chiefly concentrated on the influence of impurities in the steel, such as manganese, in affecting its rate of corrosion. Mr. Whipple's investigations, however, indicate that the surface condition of the metal is even more important than its chemical composition, and that the mill scale adhering to the surface of steel plates is chiefly responsible for the pitting which has been the principal source of trouble in steel pipes for water conduits.

Mr. Whipple is not, we believe, the first investigator who has called attention to the action of mill scale in producing corrosion upon steel; and specifications, we believe, are extant requiring the removal of mill scale from steel plates for some purposes. Mr. Whipple's tests, however, bring out more clearly than before the manner in which mill scale causes pitting by producing those minute electrical currents between different parts of the plates which are now believed to be the chief agency in causing corrosion.

It may seem at first sight a little remarkable that mill scale should cause corrosion of steel, since the scale is an iron oxide and it is well known that closely adherent iron oxide acts as a protection to the metal beneath. The old Bower-Barff process and the bluing of steel tools both consist in the production of a thin but even coating of oxide over the surface of the metal, which protects it from further oxidation. Numerous engineers, too, contend that iron-oxide paints are among the best for protecting iron and steel from corrosion. Mr. Whipple's investigations indicate, however, that the reason why mill scale causes such deleterious action upon the sheet to which it is attached is its varying thickness and varying composition with consequent variations in its electrical relations to the metal beneath it.

If Mr. Whipple's conclusions are to be accepted at their face value, it is evident that some means should be devised for systematically removing mill scale from steel plates to be used for water conduits; and if it could be done at a reasonable cost, the treatment ought to be extended to structural steel as well. On the other hand, if a process were to be devised for removing the mill scale at the mill before shipment, it would undoubtedly be necessary to apply some sort of protective coating to the plate immediately after the cleaning. Experience in cleaning structural steel with the sand blast has showed that the bright surface of the steel is very rapidly oxidized by exposure to the air, whereas the surface covered with mill scale is more or less resistant to corrosion for a time.

There should, however, be no great difficulty in applying, at no very great expense, some sort of moisture-repelling treatment to the clean steel surface after the mill scale is removed. Such thorough cleaning and protection of steel plates and shapes at the point of original manufacture would make very much easier the task of their protection with paint or other materials in the finished structure and would add greatly to their life.

Dredging Costs

On another page of this issue we publish the fourth article which has appeared in this journal within the present year summarizing large-scale government dredging operations in North America. In comparing the cost of dredging operations in Canada with the work done by the United States government plants, described in our issue of May 9, we wish to call attention to the extreme difficulty in making fair comparisons not only between the two countries but between work done in different sections of the same country. For example, the dredging season in Canada is much shorter than in most sections of the United States where extensive dredging operations are in progress; and even on the Canadian works described in this issue, the length of the dredging season varies in different parts of the Dominion between the wide limits of 3½ to 9 months.

It is a difficult thing to compare the operating costs of two dredges working in different sections of the country in different kinds of material and under greatly varying weather conditions. Furthermore, the cost of repairs varies greatly from one year to another, so that it is often entirely unfair to take the work of a dredge for one season only

for comparison with the work of other dredges for the same season. Official reports are often not explicit as to repairs, their full cost, time lost, etc., and often omit other conditions which are large elements in the total cost of the work. Accurate comparisons can, therefore, only be made for an extended number of years and under similar conditions.

We have on previous occasions called attention to the abuse of published cost data and the caution required in its indiscriminate use, not only for purposes of comparison but in making estimates for new work. These precautions should be borne in mind in making use of the data on dredging contained in these four articles. On the other hand the data given in the articles are taken from such a large number of operations that the law of averages makes the final totals and unit prices well worth record as a general guide to the estimating engineer.

Advice to Those Who Walk on Railway Tracks: Don't.

A great deal is said from time to time concerning the dangers and casualties of travel on American railways. There is great agitation, too, concerning the numerous casualties to railway employees. We would utter no word against any effort to increase the safety of both passengers and workmen employed by railways, but there is a reform comparatively easy to effect by which twice as many lives can be saved per annum as all the lives lost among railway passengers and railway employees combined. Twice as many persons were killed on railways last year who were neither employees nor passengers, as were killed of employees and passengers combined. The exact figures are: 299 passengers killed and 2928 employees killed in accidents of all sorts in railway service, while during the same year the total number of other persons suffering death on the railways was 6438. A few of these deaths of persons not employees nor passengers were of tramps and other persons stealing a ride on freight trains, and about a sixth of the whole occur at grade crossings; but all the remainder are to be charged to the fatal American habit of walking on the railway track.

It is a fact, therefore, that the railways kill more persons who are walking on the tracks, where they have no business to be, than all that are killed in all the train accidents and in all other casualties connected with railway operation.

Of course, not one person in ten thousand who walks on the railway track has any idea that he is doing anything in any way dangerous. He invariably assumes that he can hear or see any train approaching long enough before it reaches him to take the step or two away from the track which puts him in safety. It is noteworthy that railway section men whose business it is to work upon and walk along the track seem to suffer few casualties by being run down. They become accustomed to watching for trains.

Of course the only way to stop the accidents to trespassers on railway tracks is by such thorough fencing and stringent laws against trespassing on the tracks as have been put in force in most other countries. Such practice and such laws ought by all means to be established in the densely populated sections of the country.

There are many remote regions, however, where the railway track is in places the only highway. We doubt not that many of the readers of ENGINEERING NEWS engaged in engineering field work, for example, find it necessary very often to walk along railway tracks. We think it worth while, therefore, to give a word of warning as to the assumption that a train can always be heard by a person walking on the track while it is still a considerable distance away. This is not always the case. The noise made by a fast railway train is chiefly directed away from the train at the side. Comparatively a small portion of the noise is projected along the track in front of the train. Any other unusual noise at the same time may divert a person's attention from the noise made by an approaching train.

Another reason why trains may come upon a person walking on the track before he realizes their approach is a quality that sound possesses in common with other wave phenomena, although to a less degree, of traveling in straight lines. Thus a fast train approaching a sharp curve on the concave side of which there is high ground and on the convex side a broad plain will give a person on the curve almost no warning of its approach until it swings into view a short distance away.

Walking on a road with two or more tracks is particularly dangerous. A large portion of accidents to trespassers occur on double-track roads where a man in getting out of the way of one train steps onto the other track in front of another train which he has not seen or heard.

It seems worth while, therefore, to set down the following simple rules which should be observed by everyone who walks on the railway track, as follows: (1) Keep constant watch of the track both in front and behind, (2) watch and listen with particular care when approaching a curve, while on the curve and after passing the curve, (3) when walking on a double-track road, keep on the left-hand track and do not fail to keep watch also in the rear, since reverse movements are sometimes made on this track, (4) it is better to walk beside the track than to walk the ties, (5) when tempted to walk on the track, remember that you are placing yourself in greater danger than exists in the most hazardous class of railway employment, and choose some other path!

The Sentimental Opposition to Reservoirs for River Regulation

Those who plan to effect river regulation by storage reservoirs on the large scale now being widely advocated, have two large obstacles to overcome. The first, which has already been discussed at length in these columns, is to overcome the engineering difficulties and work out a plan which will provide a water-storage volume that will effect benefits of greater value than the expenditure necessary to provide it. The second obstacle is the very natural prejudice which will be felt by those whose property, places of business and homes will be flooded by the proposed reservoirs.

Many engineers who have had experience in the construction of large reservoirs for municipal water supply can testify to the intense opposition which every such enterprise has to encounter from those who live on the territory to be destroyed. Delegations from such districts are able to make out a case which appeals powerfully to a state legislature or legislative committee. In most cases where a city has taken large areas for water-supply reservoirs, as New York has done in the Croton watershed, or Boston in the Nashua watershed, the city has had to compensate for its elimination of industries, villages, cemeteries and farmsteads by paying not only the actual value of the property destroyed, but a large additional amount for what may be termed sentimental damages.

Reduced to its lowest terms, the proposition to prevent floods by reservoir construction means simply making the flood overflow occur on the upper valleys of a river's course instead of lower down.

A good idea of the strong opposition which the section to be "reservoired" is certain to manifest is furnished by an editorial in the recent number of the *Oil City Derrick*, commenting on the reservoir plan of the Pittsburgh Flood Commission as it would affect the upper Allegheny valley. We print extracts from it as follows:

MORE DAM NONSENSE

When the snows melt in the spring along the headwaters of the Allegheny and Monongahela, a small portion of Pittsburgh is disturbed by floods which inconvenience a few of the people for a week or ten days. The ground flooded may be to the amount of 40 acres or less, on which buildings are located.

When the people built on this land they were fully aware of the yearly occurrence of the floods, and they orig-

inally got this land cheaper on account of this inconvenience than if they had selected land above the flood tide. The location of this portion of the city is an invitation to be washed and flooded whenever there is an unusual rainfall, or the two rivers come out in the spring together.

This condition has caused some parties to see a great opportunity to reform the natural course of things with the aid of National and State money, and exploit a wonderful series of dams in the Allegheny and Monongahela which shall keep Pittsburgh from getting its toes wet. These parties have formed what is known as the Pittsburgh Flood Commission, which has assumed to itself the power of regulating the flow of waters in our streams and closing the river to navigation.

The plan for the Allegheny River between Oil City and Irvington is to build one dam just below the mouth of Panther Run, which shall have a breast of 63 ft. above the normal level of the water, and a crest of 810 ft. This will back the water up to a height of 9 ft. at the face of the second dam just below Tionesta. This one is to have a breast of 66 ft. With this dam a lake will be formed to a point two miles above Tidioute, where a third dam will be built 54 ft. high. The latter will back the water up to a point two miles below the mouth of the Brokenstraw at Irvineton.

The estimate of the cost, including damages for the first dam, is $1,219,900, for the second $3,057,000, and for the third $1,386,000, a total of $5,662,900. This estimate is supposed to cover the building of the dams, the payment of damages to ten towns of various size, which would be wholly or partially destroyed; to the farms and buildings which would be flooded; to the hundreds of oil wells and leases that would be wiped out, and to pay for the complete destruction of the Pennsylvania R.R., from Oil City to Irvineton, or the cost of its establishment at a higher grade.

Anyone familiar with the territory to be invaded by this wild scheme will at once see that the estimate is too low. One omission is the estimate for the first dam is the assumption that no oil wells will be destroyed, whereas there will be over 100 put under water, besides many promising locations. All the buildings along the river at Walnut Bend, the greater part of Oleopolis, all the cottages at Henry's Bend, Eagle Rock, the hotel at President, most of West Hickory and East Hickory, all of Middletown and Endeavor, the cottages at Trunkeyville, the lower part of Tidioute and the houses on both sides of the river to Irvineton will be submerged, and the beautiful valley be made a waste.

The whole scheme is a visionary one. It is not impossible, but its object and the benefits to be derived from it are not so valuable as that of the property and the privileges which would be destroyed to obtain it.

It may do for the Pittsburgh Flood Commission to dream about, and imagine the pleasure they would have in seeing the Federal Government and state spending the people's money for a scheme whose object interests only a few people; but to those living in this section the destruction of their homes, their industries, and the wiping out of whole communities, the thought is abhorrent.

An Early Triumph of American Locomotive Engineering

A recent issue of our London contemporary, *The Engineer,* brings to light a bit of history in connection with the early days of the railway era, which is of interest to American engineers. It is the fact that in 1839 eight locomotives built by Norris & Co., of Philadelphia, were exported to England to operate the Lickey Incline on the Birmingham & Gloucester Ry. We quote from our contemporary as follows:

Although the Lickey incline—two miles and one furlong, at 1 in 37½—on the Birmingham & Gloucester Railway is neither the steepest nor the longest in the kingdom, it is the steepest incline to bear the heaviest traffic. Like many other early inclines it was designed for cable traction, but it has always been worked solely by locomotives.

Both Stephenson and Brunel ridiculed the idea of working the Lickey inclined plane other than by stationary engines. Captain Moorsom stated, however, that "in America he had seen locomotives go up worse gradients than that," and he therefore induced the directors to order eight of those climbers from Norris and Co., of Philadelphia, at a cost of £1600 apiece, "including the duty of 20%." The first four reached this country in the spring of 1839.

These engines had a four-wheeled leading bogie, a single pair of driving wheels placed in front of the fire-box, and outside inclined cylinders. All the wheels were of chilled cast iron. The bogie wheels, which had no tires, were 2½ ft. in diameter; the diameter of the driving wheels was 4 ft. The diameter of the cylinders was 10½ in., the length of stroke 18 in. Certain alterations were carried out to the engines on their arrival. Their tenders were discarded, and the iron fire-boxes were replaced by copper ones. A tank, holding 400 gallons of water, was placed on the boiler, and the coke was carried in sheet iron boxes on the footplate. Thus the weight upon the driving wheels was increased from 8 to upwards of 10 tons. The general summary of their work shows that with a maximum load of 53½ tons they ascended the Lickey at a speed of between 8 to 9 miles per hour, and that with the normal load of 33 tons the speed increased to between 12 and 15 miles per hour.

The above quotation is replete with touches which shed a curious light on the customs of a bygone era. At the very opening is our contemporary's reference to the length of the grade, as we would call it, as "two miles and one furlong." That is a curious illustration of the extent to which ancient weights and measures, long discarded in America, still survive in the old country.

To many of the younger generation of engineers it will probably be news that in the early days of the railway era it was common to locate railways with inclined-plane sections to be operated by cables, where grades had to be used which were considered too steep for locomotive operation. It must be remembered that the early locomotives were so light that they had very low hauling power.

That the two greatest railway engineers of that day considered a grade of 1 in 37½ (or 2.6%) as too steep to be operated by locomotive traction is a notable illustration of the limitations of the early locomotives.

Even at the present day there are isolated examples of the use of inclined planes to be operated by cables connected with railway location, the most recent probably being the use of an inclined plane to ascend a steep escarpment on the British East African Ry.

Reference to Colburn's "History of the Locomotive Engine" gives further interesting particulars of these early Norris engines. The founder of the concern was William Norris. His firm, Richard Norris & Son., of Philadelphia, built one engine in 1832, one in 1833, one in 1834, two in 1835, eight in 1836 and one hundred in the year 1854. Out of 1000 engines turned out at the Norris works, 17 were exported to the Birmingham & Gloucester Ry. and 153 to the Continent of Europe.

It would seem from Colburn's history that Captain Moorsom had good foundation for his confidence in Norris & Co.'s work, for three years earlier, in 1836, a Norris locomotive had won out in a notable test on an inclined plane with a gradient of 1 in 14, or 369 ft. per mile, on the Columbia R.R. near Philadelphia. The Norris locomotive in this test had a weight of "6 tons, 8 cwt., 2 quarters" and it drew an additional load of "8 tons, 11 cwt. and 2 quarters" up the plane, which was 2800 ft. long, making a speed on the run of over 15 miles per hour. The designer of this Norris engine was Joseph Harrison, to whom, with Andrew M. Eastwick, is given the credit for the original invention of equalizing levers upon a locomotive for distributing the weight upon the driving wheels. These locomotives were also notable for the use of a traction-increaser, a part of the weight of the tender being thrown upon the rear drivers to obtain maximum tractive power.

The engines built to work the Birmingham & Gloucester Ry. incline were somewhat heavier than the Columbia Ry. locomotives, their weight being given by Colburn as 9 tons 11 cwt.. He states that their indicated power could hardly have exceeded 90 hp. when climbing the grade.

As showing the reputation of American mechanical engineers in foreign countries at that early day, it may be mentioned that Joseph Harrison, the designer of these locomotives, afterward assisted the famous Ross Winans in building the rolling stock of the St. Petersburg & Moscow Ry., while William Norris, the founder of the Norris Works in Philadelphia, as a result doubtless of the large exportations of his locomotives to Europe, afterward established a locomotive works in Vienna.

It may be imagined that the exploit of these early American locomotive builders in building and selling locomotives to England, where the machine had originated, aroused no little jealousy among the English locomotive makers of that day. We quote from *The Engineer* further as follows:

The importation of American locomotives appears to have aroused a good deal of feeling among English builders of the period. Mr. Edward Bury, manager

of rolling stock to the London & Birmingham Ry., sent an engine to the Lickey, but it failed to take its own weight up the incline. In 1841 a further order for eight more Norris locomotives was given, and an American newspaper published the taunt that "the English could make inclines, but had to come to America for engines to work them." At last Mr. J. E. McConnell, the Birmingham & Gloucester Company's locomotive superintendent, took up the challenge. In 1845 he built a powerful tank engine at the Bromsgrove shops, which proved itself capable of hauling a load of 70 tons up the incline.

The most quaint and interesting thing of all in the story by our English contemporary, however, relates to the explosion of the boiler of one of these locomotives. We quote further as follows:

On Nov. 10, 1840, the boiler of one of the engines exploded at Bromsgrove Station, and two of the American engineers who had come over to supervise them were terribly wounded and succumbed to their injuries. The names of these men were Thomas Scaife and John Rutherford, and their remains were interred side by side in Bromsgrove Churchyard. On the top of each headstone is carved a technically correct representation of a Norris locomotive placed within an oval shield. Rutherford's headstone was erected by his widow, but the inscription on Scaife's states that it was put up by his fellow-workmen. Scaife's epitaph, which is arranged in two columns, runs as follows:—

Column I

"My *engine* now is cold and still,
No water does my *boiler* fill;
My *coke* affords its flame no more,
My days of usefulness are o'er.
My *wheels* deny their wonted speed,
No more my guiding hand they need.
My *whistle*, too, has lost its tone,
Its shrill and thrilling sounds are gone.
My *valves* are now thrown open wide."

Column II

"My *flanges* all refuse to guide.
My *clacks*, also, though once so strong,
Refuse to aid the busy throng.
No more I feel each urging breath,
My *steam* is now condens'd in death.
Life's *railway* o'er, each station's past,
In death, I'm stopp'd, and rest at last.
Farewell, dear friends, and cease to weep,
For Christ, I'm safe, in Him I sleep."

To the credit of the pioneer American locomotive builders, it must be added that the locomotive whose boiler exploded was not one of the American engines. In the very next issue of *The Engineer* a correspondent sends a correction as follows:

The engine which blew up in 1840 was not one of the Norris bogies. It was an experimental engine designed by Dr. Church, of Birmingham, called the "Surprise." It had done a good deal of ballasting work on the London & Birmingham Railway, and had run some light goods trains on the Grand Junction. Being a bad steamer it had been lying unused a long time, but after some alterations to the grate was borrowed by the Birmingham & Gloucester Co., to see what it could do. The grate was in a large water-surrounded horizontal tube, and it was supposed that water dripping from the vertical boiler beyond the bridge had corroded the inner casing. Anyhow, this gave way at the bottom, whilst the engine was standing in a siding at Bromsgrove. Several men were injured besides the two who were killed. These were both in the employ of the Birmingham & Gloucester Railway, Scaife as driver and Rutherford as a foreman, or fitter, in the locomotive department, and were not Americans sent over with the Norris engines.

Dredging Operations of the Dominion of Canada

By Emile Low*

Like the United States, the Dominion of Canada operates a government dredging plant, which is divided into two sections, one under the direction of the Chief of Engineers of the Department of Public Works, and the other under the direction of the Superintending Engineer of the Department of Marine and Fisheries.

The dredges of the first-named department operate in the harbors and rivers of the various provinces of New Brunswick, Prince Edward Island, Ontario, Quebec, Manitoba, Saskatchewan, Alberta, and British Columbia. This fleet consists of 48 dredges and various other vessels to a total of 75. Of these dredges 31 are dipper, 8 orange-peel bucket, 3 hydraulic, 3 elevator, and 1 each of the suction and elevator, agitator-suction, and scraper-suction types.

The fiscal year of the Dominion of Canada begins Apr. 1 and ends Mar. 31, and this article deals with the operations of the year 1910-1911, as abstracted from the official report. For this period the total work done under the Department of Public Works was 4,051,182 cu.yd., excavated at a total cost of $612,714, which is an average cost per cu.yd. of 15.12c., which will be seen to be considerably higher than the average cost for similar work done in the United States.*

The dredging operations done by the 10 dredges of the Department of Marine and Fisheries, in the St. Lawrence Ship Channel, totaled 5,600,050 cu.yd. of material, excavated at a total cost of $576,838, at an average cost of 10.3c. per cu.yd.

The operations of the dredges under the Department of Public Works are shown in detail in Tables I, II and III. The time of dredging is during the spring, summer and fall months of the year, but the length of time varies greatly, ranging from 3½ to nearly 9

*606 Ashland Ave., Buffalo, N. Y.

*See Eng. News, May 9, 1912, pp. 886-889.

TABLE I. OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE DEPARTMENT OF PUBLIC WORKS, DOMINION OF CANADA, FOR THE FISCAL YEAR ENDING MARCH 31, 1911

	Maritime Provinces													
Name of Dredge	St. Lawrence		Prince Edward		Geo. McKenzie		New Brunswick		W. S. Fielding		Montague		Restigouche	
Type	Elevator		Dipper		Dipper		Dipper		Suction & Elevator		Dipper		Hydraulic	
Dimensions, ft	170-0x30-0		80-0x26-0		86-6x29-6		78-0x29-0		147-0x42-0		90-0x38-		161-8x30-0	
Greatest working depth, ft	28		25		26		18		54		26		40	
Least working depth, ft	10		9		7		7		16		7		14	
Average daily capacity, cu.yd	1400		450		300		500		5000		700		2300	
Distribution of cost and percentage of total cost	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent	Amount	Per cent
Wages	$6,705.34	19.4	$5,006.32	32.7	$2,027.27	36.1	$5,491.76	30.9	$15,414.20	33.3	$5,521.19	29.8	$6,357.93	47.0
Coal	2,597.98	7.5	882.12	5.8	913.27	16.3	677.07	3.9	4,110.03	8.9	1,465.51	8.0	1,274.76	9.4
Provisions	2,237.06	6.5	1,126.11	7.4	463.32	8.3	1,358.72	7.6	3,664.87	7.9	1,617.07	8.7	1,603.72	11.9
Stores	349.77	1.0	792.91	5.2	329.94	5.9	626.83	3.6	930.25	2.0	515.07	2.8	794.70	5.9
Equipment	267.15	0.7	409.93	2.7	43.39	0.8	521.38	2.9	1,543.98	3.3	522.22	2.8	596.08	4.4
Water	23.48	0.1	358.80	2.3	198.00	3.6	60.20	0.3	1 007.94	2.2	48.20	0.2	361.76	2.6
Repairs	11,719.38	33.9	1,353.41	8.9	508.77	9.1	3,813.60	21.5	10,203.19	22.0	2,811.22	15.2	1,661.21	12.3
Pilotage	0	0	52.70	0.3	10.00	0.2	0	0	1,100.00	2.4	265.00	1.4	310.45	2.4
Towage	10,320.00	30.0	5,263.83	34.4	1,006.83	17.9	5,060.34	28.5	5,326.50	11.5	5,503.00	29.8	0	0
Wharfage	0	0	0	0	37.00	0.6	105.12	0.6	2,867.87	6.2	35.00	0.2	0	0
Contingencies	319.83	0.9	44.27	0.3	74.90	1.2	37.24	0.2	140.48	0.3	207.45	1.1	561.53	4.1
Totals	$34,539.99	100.0	$15,290.40	100.0	$5,612.69	100.0	$17,752.26	100.0	$46,309.31	100.0	$18,513.93	100.0	$13,522.14	100.0
Tug Helena									16,815.41					
Tug Hercules									9,332.01					
Tug Canso									11,187.05					
Tug Rona					1,572.63						133.17			
Superintendence	248.45		110.01		51.75		127.74		601.73		133.17		97.70	
Grand totals	$34,788.44		$15,400.41		$7,237.07		$17,880.00		$84,245.51		$18,647.10		$13,619.84	
Material dredged, cu.yd	113,610		32,219		27,430		72,465		460,970		91,400		87,050	
Cost per cubic yard, cents	30.6		47.8		26.4		24.7		18.3		20.4		15.7	
Locality of dredging	Restigouche R. N. B.		Nine Mile Ck., P. E. I.		Gaspereau R., N. B.		Grassy Island, N. B.		St. Johns, N. B.		Summerside, P. E. I.		Bathurst, N. B.	
Character of material	Silt		Clay, Mud, Hard-pan, Gravel		Clay, Mud, Sand		Clay, Mud, Sand		Clay, Sand Boulders		Clay, Mud, Stone		Mud, Sand, Gravel	
Actual time dredging, hrs.-min	763-25		1044-15		751-10		1158-00		775-42		1165-01		572-00	
Working dates, year 1910	June 13-Nov. 10		Apr. 20-Dec. 10		July 16-Nov. 4		June 1-Dec. 10		Apr. 11-Dec. 21		Apr. 18-Dec. 15		July 27-Nov 9	
Hourly rate of dredging, cu.yd	149		31		36		62		595		79		152	

TABLE II. OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE DEPARTMENT OF PUBLIC WORKS, DOMINION OF CANADA, FOR FISCAL YEAR ENDING MARCH 31, 1911

Provinces of Quebec and Ontario

Name of Dredge	Challenge	Desche-nes	Industry	Internat-ional	Mattawa	Nipissing	No. 2	No. 3	No. 5	Ontario	Ottawa	Progress	Prince Willie	Queen	Quebec	Sir Richard	St. Louis	17 Dredges
Type	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	Dipper	
Dimensions, ft	77-6x28	50x20	133-4x44-8	110x42	75-6x28-4	75x29	66x22	61x25	85x29	72x25	103x43	91x34-4		66x28	106-9x36-8	87x33-9	61x25	
Greatest working depth, ft	21	16	28	58	20	22	15	16	27	23	35	30		20	42	20	16	
Least working depth, ft	8½	6	14	10	12	9	6	6	9	10	12	10		7	16	9	6	
Average daily capacity, cu.yd	500	250	3,000	1,250	850	575	300	450	500	550	850	1000		400	2700	600	325	
Distribution of cost	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Total Amt.
Wages	$4,915.16	$4,257.82	$12,820.58	$7,403.61	$4,625.59	$6,242.09	$5,740.78	$4,339.29	$7,365.73	$3,779.11	$9,621.57	$10,576.56	$1,030.91	$5,029.53	$13,128 34	$4,528.22	$3,737.84	$109,142.73
Coal	1,798.79	1,320.54	4,534.57	3,492.30	2,059.18	1,778.56	1,116.40	871.27	664.67	1,322.65	3,826.16	3,772.67	500.01	1,786.66	3,793.63	1,855.61	974.81	35,468.48
Provisions	1,256.36	1,245.53	3,837.94	2,354.35	1,517.62	1,274.92	1,817.68	1,306.24	1,097.36	1,247.60	2,818.99	3,599 77	342.00	1,784.71	4,263.12	1,343.97	1,260.77	32,367.83
Stores and equipment	357.09	719.17	3,833.81	743.82	422.76	293.72	261.23	234.95	335 22	286.48	707.04	589.61	97.39	309.79	3,654.32	362.85	231.51	13,440.76
Repairs	1,025.98	1,377.00	3,429.15	2,618.74	2,981.84	3,015.62	842.94	1,895.00	1,813.57	3,692.59	3,698.56	2,271.86	14.20	1,703.28	3,049.98	970.56	1,727.60	36,128.47
Pilotage and towage	7.00	408.00	1,600.00	108.50	49.50	30.00	0	202.70	275.00	0	0	734.50	82.10	0	1,435.75	15.00	67.00	5,015.05
Contingencies	51.66	578.20	628.21	648.04	1,222.63	78.55	152.73	164.30	97.50	307.16	781.24	619.70	4,395.69	383.03	1,015.69	212.34	160 14	11,497.81
Totals	$9,412.04	$9,906.16	$30,684.26	$17,369.36	$12,879.12	$12,713.46	$9,931.76	$9,013.75	$11,649.05	$10,635.59	$21,453.56	$22,164.67	$6,462.30	$10,997.00	$30,340.83	$9,288.55	$8,159.67	$243,061.13
Material dredged, cu.yd	39,050	23,258	371,258	123,425	72,645	39,975	24,392	45,654	10,951	106,700	49,470	131,850	30,175	8,644	278,900	74,920	26,321	1,457,588
Cost per cubic yard, cents	24.1	42.6	8.3	14.1	17.7	31.8	40.7	19.7	106.4	10.0	43.4	16.8	21.4	127.2	10.9	12.4	31.0	16.7
Locality of dredging	Ottawa, Rigaud and Richelieu Rs.	Lake Deschenes	North Shore Lake Erie Georgian Bay	St. Charles R. Quebec Bridge Levis	Lake Nipissing	Ottawa Richelieu Rs.	Lievre R.	St. Lawrence and Ottawa Rs.	St. Lawrence R.	Lake St. Clair	St. Lawrence Richelieu Rs.	St. Lawrence R.		Lake Timiskaming	Lakes Ontario & Erie	Lake Ontario	St. Lawrence Richelieu Rs.	
Character of material	Clay, sand, gravel	Clay, sand	Sand		Sand, Clay mud, silt	Clay, boulders, hard pan	Clay	Clay, sand	Hard clay, boulders	Clay, sand silt	Clay, sand	Hard clay sand		Blasted boulders		Clay blasted rock	Clay, sand boulders	

The average working time per day (excluding Sundays) is from 3½ to 8 hr., indicating a large proportion of delays.

MARITIME PROVINCES

The location of dredging operations in the maritime provinces is generally at the ocean harbors, usually the deepening of tidal streams, the depth of dredging varying from 6 to 23 ft. The dredged material is mud, sand, hard clay and shelly rock.

The best record made by any dredge of the first group was by the suction-elevator dredge "W. S. Fielding" in the harbor channel at St. John, N. B., where a total excavation of 460,970 cu.yd. was made at a total cost of $84,245, or an average cost per cu.yd. of 18.27c.

PROVINCES OF ONTARIO AND QUEBEC

In Table II, for the provinces Quebec and Ontario, the dredge "Industry" shows the largest output of 371,258 cu.yd., and the lowest cost per cu.yd. of 8.26c. This dredge was operated at the railroad terminals on the north shores of Lake Erie and Georgian Bay, where the depth of dredging ranged from 14½ to 24 ft., and the material was silt and sand.

The following table shows the total expenditure of the Quebec and Ontario dredging plant of 17 dipper dredges, and percentage of total cost of the different items of wages, etc.:

Items	Cost	Percentage
Wages	$109,142 73	44 9
Fuel	35,468 48	14 6
Provisions	32,367 83	13 3
Stores and equipment	13,440 76	5 5
Repairs	36,128 47	14 9
Pilotage and towage	5,015 05	2 1
Contingencies	11,497 81	4 7
Total cost	$243,061 13	100 0

WESTERN PROVINCES

Dredging was also done in Manitoba, Alberta, Saskatchewan, and British Columbia, but the annual reports for these districts give few details except for the four dredges employed in British Columbia. Table III shows the operations of these four dredges. Of these the scraper-suction dredge "Fruhling" shows the best record of 924,800 cu.yd., excavated at a total cost of $46,983, or an average cost of 5c. per cu.yd.

LABOR—The following information relative to the number of men employed on dredges and the wages paid has been kindly furnished by A. R. Dufresne, Assistant Chief Engineer, Department of Public Works of Canada, and will be found of interest for comparison with similar work in the United States:

On dipper dredges of from 1 to 2½ cu.yd. bucket capacity, the number of men and wages paid are as follows:

1 Captain, who also acts as runner	$75 to $100	per month
1 Cranesman	50 to 65	per month
1 Fireman		40 per month
2 Deckhands, each		35 per month
1 Scowman		35 per month
1 Watchman		35 per month
1 Cook		30 per month

TABLE III. OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE DEPARTMENT OF PUBLIC WORKS, DOMINION OF CANADA, FOR THE FISCAL YEAR ENDING MARCH 31, 1911.

Province of British Columbia.

Name of Dredge	King Edward	Fruhling	Ajax	Mudlark
Type	Agitator-Suction	Scraper-Suction	Dipper	Dipper
Dimensions, ft.	125x32	187x34–6	110–5x40	90–2x30–4
Greatest working depth, ft.	45	45	40	40
Least working depth, ft.	6	16	18	13
Average daily capacity, cu.yd.	4,500	5,000	700	650
Cost of operating	$41,538.87	$37,948.10	$36,205.49	$22,200.50
Cost of repairing	15,078.78	8,835.58	8,815.77	7,011.66
Total Cost	$56,617.65	$46,983.68	$45,021.26	$29,212.16
Material dredged, cu.yd.	443,650	924,800	213,190	146,810
Cost per cu.yd., cents	12.7	5.0	21.1	19.9
Locality of dredging	Vancouver South Westminster Nanaimo	Fraser R.	Victoria	Victoria
Character of material	Mud, clay, silt gravel, hard pan	Sand gravel	Mud-clay, sand, gravel	Mud-clay

The cook is allowed $15 per month for each man, for which he boards the crew, supplying provisions, ice, etc.

On the larger dredges of 4 to 10 per cu.yd. bucket capacity, the captains are paid $125 per month, and the crew consists of the following men, varying a little according to localities and different machinery on board:

1 Assistant runner	$50 to $75 per month
1 Cranesman	50 to 65 per month
1 Fireman	40 per month
1 Oiler	40 per month
3 Deckhands, each	35 per month
2 Scowmen, each	35 per month
1 Watchman	35 per month
1 Cook	45 per month
1 Assistant Cook	20 per month

St. Lawrence Ship Channel

The dredging operations over which the Department of Marine and Fisheries have jurisdiction comprise the deepening of the River St. Lawrence Ship Channel between Montreal and Father Point, a total length of 340 statute miles. The length of the channel actually requiring improvement by dredging from Montreal to the Traverses is about 70 miles. The length of the 30-ft. channel actually completed at the close of navigation, 1910, was 64 miles, leaving 6 miles to be dredged in order to give a clear depth of 30 ft. at low tide or during the lowest stage of the river level. The completed channel has a minimum width in the straight portion of 450 ft. and in the curved sections of from 500 to 800 ft. Of the work remaining to be done since this report was issued, there is about 1½ miles of shale rock at Cap à la Roche, which will take from two to three years to excavate.

The dredging plant operated in the St. Lawrence Ship Channel comprises 10 dredges, 6 of the elevator type, 2 suction-hoppers, 1 dipper, and 1 hydraulic dredge, and other vessels to a total of 74. The elevator type of dredge is extensively used in Europe, but has found but little favor in the United States. The Engineer Department at Large, U. S. Army, owns and operates three dredges of this type, the "Alabama," the "Oskosh," and the "Malta," which have a rated dredging capacity per hour of 213, 200 and 120 cu.yd., respectively, in soft mud, clay, sand, muck, and gravel. As this Canadian fleet is the only large fleet of elevator dredges assembled on this side of the Atlantic, some information relative to its operation may be of interest to engineers.

The oldest dredge in the service is the "Laval," the hull of which is of wood, constructed in Ottawa in 1894. This dredge is provided with a cast-steel bucket for work in rock and other hard material such as is found in the Cap Levrard Channel, where the material is very hard and difficult to dredge, being hardpan, clay and stones. Here the hourly rate of dredging was 73 cu.yd., costing 26.61c. per cu.yd. In clay and stones and sand and stone the hourly rate was 130 cu.yd., costing 13c. In sand the hourly rate is 159 cu.yd., but the cost was 18.84c., which is explained by the fact that the working time was a small percentage of the whole time spent on the work.

The dredge "Laurier" was built in the government shipyard at Sorel in 1897. The hull is of wood, and the buckets similar to those of the "Laval." The "Lady Aberdeen" is a later dredge and was also built at the Sorel shipyard in 1900. The hull is of steel and the buckets of cast steel for work in hard material. The hourly rate of this dredge at Pointe-aux-Trembles in clay, sand and stone, was 129 cu.yd. per hour, costing 12.89c. per cu.yd. While digging in slate rock and stones at the Cap Charles curve, the hourly rate was 75 cu.yd. and the cost 26.83c.

TABLE IV. OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE DEPARTMENT OF MARINE AND FISHERIES, DOMINION OF CANADA, FOR THE FISCAL YEAR ENDING MARCH 31, 1911, RIVER ST. LAWRENCE SHIP CANAL

Name of Dredge	Laval	Laurier	Lady Aberdeen	Lady Minto	La Fontaine	Baldwin	J. Israel Tarte	Beaujeu	Galveston	
Number of Dredge	1	2	3	4	5	6	7	8	9	10
Type	Elevator	Elevator	Elevator	Elevator	Elevator	Elevator	Hydraulic	Suction Hopper	Suction Hopper	Dipper
Where built	Ottawa	Sorel	Sorel	Sorel	Sorel	Sorel	Toronto	Sorel	Germany	Sorel
When built	1894	1897	1900	1900	1901	1902	1902	1907	1904	1910
Hull	Wood	Wood	Steel	Steel	Wood	Wood	Steel	Steel	Steel	Steel
Dimensions, ft.	150x30x14	163x32x14	148x32x13	148x32x13	168x32x14	165x34x14	160x42x125	264x45x20	233x39x15½	132½x42x11½
Average draft, ft.	11	10	8½	8½	9	8	6	15	14	10.6
Greatest working depth, cu.yd.	42	45	42½	42½	45	42½	47	65	55	50
Average daily capacity	1,000-2,000	1,000-2,000	1,000-2,000	1,000-2,000	1,000-2,000	2,500-3,500	12,000-20,000			
Distribution of cost	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount	Amount
Fuel	7,726.36	7,988.11	6,491.15	6,514.86	9,982.46	7,757.65	35,544.78	11,124.94	11,134.27	2,370.82
Wages	8,257.78	8,187.67	8,188.72	8,141.75	8,247.46	7,984.87	14,322.50	12,293.19	10,340.27	3,515.47
Board	3,172.30	3,231.95	3,206.02	3,222.95	3,261.60	3,084.91	5,108.48	3,698.69	3,180.65	998.10
Stores and materials	3,576.87	2,311.23	3,518.75	4,217.63	5,127.54	5,272.55	9,842.81	4,872.31	4,113.38	1,239.90
Repairs and labor	8,848.48	7,377.46	8,985.91	7,734.22	9,378.27	15,213.53	24,779.32	10,722.87	7,954.44	2,996.71
General and office expenses	1,826.43	1,682.70	1,757.54	1,725.20	2,139.60	2,273.54	5,181.49	2,643.56	2,124.25	643.17
Floating ship, etc	2,820.72	2,820.72	2,820.72	2,820.72	2,820.71	2,820.71	0	0	0	0
Tug service	11,095.61	10,435.79	11,029.74	13,902.70	14,898.56	9,581.49	20,203.20	7,295.07	7,295.06	8,884.72
Inspection, tuning, sweeping	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03	4,232.03
Total cost	$52,156.67	$48,267.66	$50,230.58	$52,512.06	$61,088.23	$58,221.28	$119,214.61	$59,882.66	$50,383.35	$24,880.92
Material dredged, cu.yd.	309,150	216,000	275,950	399,750	304,350	375,925	2,352,200	700,400	609,600	56,725
Cost per cu.yd., cents	16.87	22.34	18.20	13.13	20.07	15.48	5.06	8.54	8.26	43.86
Locality of Dredging	Montreal floating dock approach Cap Levrard, Batiscan channel	Varennes and Cap a'la Roche curve	Pointe-aux Trembles Cap Charles curve, Grande Pointe shoal	Varennes and Cap a'la Roche curve	Varennes and Cap a'la Roche curve	Montreal floating dock approach Champlain channel. St. Anne Traverse	White buoy curve	St. Thomas channel	Beaujeu channel	Montreal floating dock approach
Character of material	Clay, sand Hard pan, stones,	Clay, Shale rock	Clay, sand Shale rock stones	Clay, shale rock, stones	Hard Clay shale rock	Clay, sand stones	Clay, very hard clay	Clay stones	Hard sand clay, stones gravel	Hard pan stones
Time of service, days	188	195	184	188	190	168	177	186	180	96
Nominal work hours, 24 per day	4,152	4,296	4,036	4,140	4,176	3,686	3,894	2,438	2,292	
Hours actual dredging	2,860	2,923	2,791	3,101	2,952	2,770	1,705	1,667	1,384	
Cu.yds. dredged per hour	108	74	99	129	103	135	1,379	420	440	
Percentage time, actual work	69	68	69	75	71	75	45	68	60	57
Number of scows filled	1,717	1,080	1,391	1,999	1,161	1,539		371	408	257
Cubic yards per scow	180	200	198	200	262	244	Pipe line	1,888	1,518	221
Depth of dredging at low water, ft.	30	30–35	30–35	30–35	30–35	30–35	30–35	30	30	30

The dredge "Lady Minto" is of the same type and design as the "Lady Aberdeen" and was also constructed at the Sorel shipyard at the same time. Although operated in the same vicinity as the "Laurier," the average cost of dredging was 11.95c. per cu.yd., against 20.76c., the average cost by the "Laurier."

The "Lafontaine" was completed at the Sorel shipyard in 1901 and also has a wooden hull and is equipped with buckets similar to the foregoing descriptions. The hourly rate of this dredge at the Varennes and Cap à la Roche curves were 162 and 74 cu.yd., respectively, in soft material and in solid shale rock. The costs were 10.94 and 29.63c. per cu.yd., respectively, or practically the same as for the "Laurier."

The "Baldwin" was constructed in 1902 at the Sorel shipyard. The hull is of wood. This dredge is provided with large built-up buckets for work in soft material, but with sufficient teeth to enable it to work in hard clay. During the season it worked at four different localities with hourly rates of 119, 242, 116 and 198 cu.yd., respectively, and an average cost of 15.48c. per cu.yd. The material was clay, sand and stone.

There is one hydraulic dredge, the "J. Israel Tarte," the hull of which is built of steel and is of the same general design as the steel hulls of the elevator dredges. This dredge was built in 1902 by the Polson Iron Works Co., of Toronto, Ont. A great amount of time was lost by this dredge during the season owing to the difficulty in obtaining steam pressure. This was due in some degree to the poor condition of the boilers, but largely to the poor quality of coal supplied. For this reason and on account of other delays the machinery was in operation only about 45% of the full working time.

The two suction-hopper dredges, the "Beaujeu" and the "Galveston," operated in clay and stones, sand, clay, stone and gravel, at an average cost of 8.54 and 8.26c. per cu.yd., respectively. One dipper dredge is also on the work, the "No. 10," which is a new machine built in 1910, and designed by John Kennedy, Consulting Engineer for the Montreal Harbor Commissioners, and is considered to be the most powerful dredge of this type afloat. Its operations were in the channel approach to the floating-dock basin, Montreal Harbor, where 56,725 cu.yd. of hardpan were removed at an average cost of 43.86c. per cu.yd. Owing to a series of breakdowns, a good showing was not made with this dredge.

EXPERIMENTAL ROCK-CUTTER—In order to facilitate the dredging of the hard shale rock at Cap Charles in the Cap à la Roche section, an experimental rock-cutter was constructed.

As it was uncertain what success would be obtained with this machine, it was decided to utilize the hull and as much of the machinery as possible of a new stone-lifter under construction at the Sorel shipyard. Therefore it was only necessary to purchase a 20-ton rock-cutter ram and hoisting winch, which were obtained from Lobnitz & Co., Renfrew, Scotland, and installed on the stone-lifter.

After the installation was completed, the rock-cutter was started to work at the section of the channel where the shale rock is very hard, and it was soon found that the rock-cutter could break up this material without difficulty. It took an average of five blows to penetrate 3 ft., the penetrations being 5 ft. apart. The broken rock was found to be of convenient size for dredging. Results proved that after the rock-cutter had gone over the ground the dredge could remove about 75% more material in a given time.

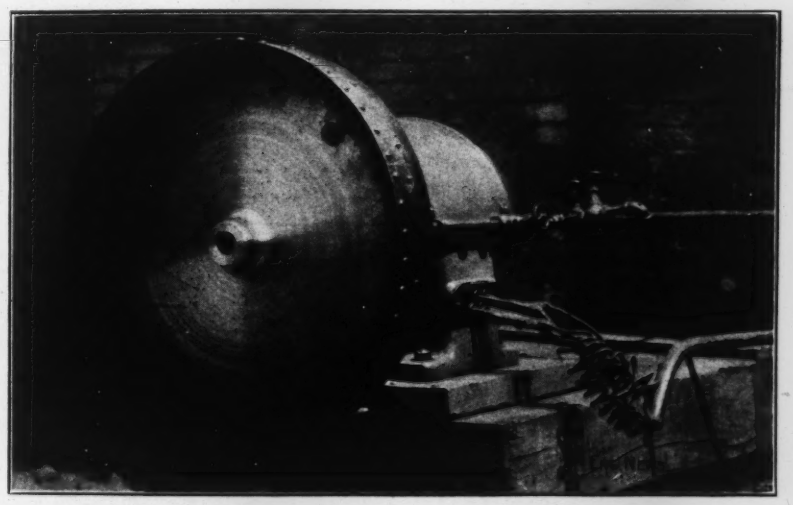

FIG. 1. CENTRIFUGAL AIR HUMIDIFIER
(Developed by H. H. Clark, U. S. Bureau of Mines.)

A Centrifugal Air Humidifier*

The U. S. Bureau of Mines has on exhibition at its Pittsburgh testing station, a machine for producing a water mist that is almost fine enough to be termed a fog.

As shown in Fig. 1, the machine consists of a hollow wheel mounted upon the shaft of an electric motor. The wheel is provided at its periphery with spray nozzles, at its hub with an opening for the admission of water, and on its back with fan blades. The back and rim of the wheel is inclosed in a steel housing that serves as a casing for the fan, as a support for air diffusion vanes, and as a shield for the revolving parts. When the wheel is rotated at normal speed by the motor, the water is admitted (under practically no pressure) to the opening in the hub, and a hydraulic pressure of more than 200 lb. per sq.in. is developed, by centrifugal force, at the nozzles in the wheel's periphery. This pressure drives the water through the nozzles in the form of a fine spray, which is seized, broken up still more, and finally carried away by the blast of air that the fan blades, on the back of the wheel, blow out all around the rim of the wheel. The dif-

*From information furnished by the U. S. Bureau of Mines, Washington, D. C.

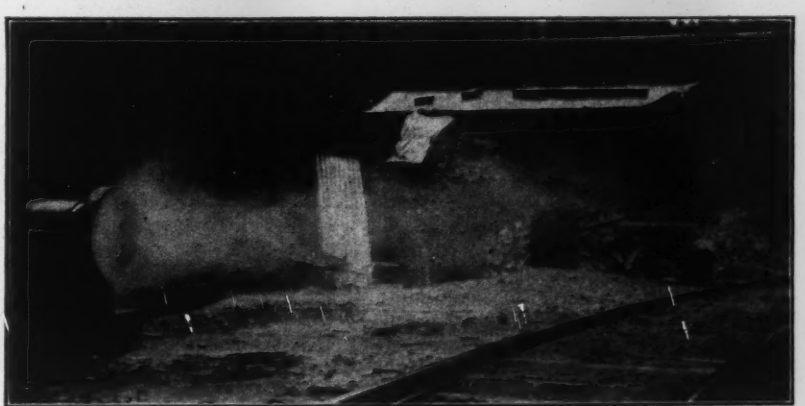

FIG. 2. CLARK HUMIDIFIER DISCHARGE 1.5 GAL. WATER PER MINUTE

fusion vanes cause the air to be discharged in the form of a cylinder whose axis is coincident with the fan shaft.

The mist produced is extremely fine and there is practically no dripping of solid water. The device was developed by H. H. Clark, one of the Bureau's engineers. It is not yet in its final form, and has not been tested in actual practice.

Smoke Abatement in Chicago

The average smoke-density of locomotives in Chicago at the present time is 14.92%, according to records made by the engineers of the Chicago Association of Commerce Committee on Smoke Abatement and Electrification. This shows a decided improvement over the record of 23.3% at the time when the city smoke commission made its report during the former city administration. The figures cover the performance of locomotives in general operation, those employed in yard service, and also those standing still (but with fires up) at terminals and in roundhouses. In the following table the territory inside the city limits is referred to as zone A, and a zone just outside the city limits is referred to as zone B. The percentage gives the ratio of actual performance to worst possible performance. That is, if a locomotive emitted dense black smoke all the time, its record would be put down at 100%. If it gave out no smoke at all, its percentage would be zero.

TABLE OF SMOKE-DENSITY OF LOCOMOTIVES AT CHICAGO.

Locomotives	City Zone, A	Outside Zone, B	Total
In general service	19.31	26.02	21.12
In yard service	16.70	23.40	18.20
At terminals and roundhouses	11.77	18.97	12.56

The total average of locomotive performance in zone A, which means for the entire city of Chicago, is 14.92%. The average for zone B is 19.12%, showing that outside of the city limits locomotive crews are not nearly so careful in the matter of smoke production. The total for zones A and B is 16.42%, which is the average density of locomotive smoke in the entire field covered by the investigations. The recent reports of city smoke inspectors give even lower averages of smoke production, but the higher figures of the committee's engineers are the result of an exhaustive investigation, substantiated by voluminous records giving 1-min. interval observations for every half-mile of track in the territory under surveillance. The method has been to station observers at an average distance of half a mile apart along the line that may be under observation, and every effort is made to keep the knowledge of the presence of the observers from the operators on the lines, lest such knowledge would have the effect of producing improved performance. These observers make records every minute for each locomotive in sight, and in this manner a train going the entire length of the line would be in turn observed by each observer stationed along the line. By putting the records together the performance of the locomotive for the entire distance is obtained.

Observations of stationary smoke-stacks and river tugs and lake vessels show that the average density of smoke from stationary stacks in the city limits is 10.27%; outside the city limits, 25.97%; total average, 13.08%. Steam vessels in zone A show 14.64%; in zone B, 26.82%; the total average being 15.47%. It is thus seen that steamers smoke up rapidly as they move away from Chicago. An investigation of air conditions is being made by a portable laboratory, which now has made air tests in 58 locations.

Heat-Treated Steel for Electric Street Car Gears*

The development of gears and pinions to meet the requirements of more severe and longer service has resulted in bringing the various methods of heat treatments and surface treatments and the use of special metals to the front. A few years ago the cast-steel gear was considered the best for electric-railway service. Today, almost every gear (and particularly the pinion) is given some character of treatment to render the metal of higher unit working stress. In some instances they are treated by being quenched in oil from a high to a somewhat lower temperature. In other cases water is used for this quenching.

The result of these processes is such that the tensile strength and the elastic limit are greatly increased in cast-steel gears, and are more than doubled in forged-steel gears or pinions. Since there is a great demand for gears and pinions in which the rate of wear will be reduced to a minimum, there have been brought forward three classes of products:

1. Those whose original soft texture has been hardened on the surface by one of the many methods of surface treatment. This results in giving a wearing surface so hard that it indefinitely prolongs the time that both gear and pinion maintain their full tooth section.

2. Low-carbon stock converted into high-carbon tool-steel stock.

3. The use of elements (such as manganese) that when combined with the steel renders the product of an extremely hard nature.

In some cases it is found that the best results cannot be obtained with the hardened products, since under the severe strain their teeth break out. In some cases high-carbon oil-treated stock is best. However, for the average condition the hardened gear and pinion will produce results in lengthening the life of both the gear and pinion to at least twice that obtained with the gear and pinion not case-hardened.

Recently there has been developed a rolled-steel gear. This gear after being machined can be case-hardened and represents the highest development in gear products.

Many remarkable claims are made for special gear and pinion products, but before any definite decision is made concerning the results, the conditions under which the results were obtained should be carefully investigated. Although no real line of demarcation can be made between the various kinds of gears and pinions, yet it may be interesting to note some of the physical characteristics of each different kind. These are given in the accompanying table, but it is not possible to obtain test specimens for case-hardened products. The hardness in the last column is obtained from tests with the Brinnel hardness gage.

For the varying conditions of service the gears are named in the inverse order of their ability to meet the more severe demands required as follows: 1, cast steel; 2, cast steel, oil treated; 3, forged steel; 4, case-hardened cast steel; 5, case-hardened forged steel; and 6, special alloy. The pinions rank as follows: 1, low-carbon forging; 2, low-carbon forging, oil treated; 3, high carbon; 4, high carbon, oil treated; 5, case-hardened; 6, special alloy or treated pinions.

To properly and intelligently decide the quality of service to be expected from any gear or pinion and particularly the recent hardened products, a machine has been developed that will imitate the gear and pinion under service conditions and will hasten the rate of wear so that in a comparatively short time the relative rate of wear of any two different products can be ascertained.

*Extract from the report of the Committee on Equipment, presented at the annual meeting of the American Electric Railway Engineering Association, at Chicago, Oct. 7-11.

TABLE OF PHYSICAL CHARACTERISTICS OF METALS FOR GEAR WHEELS.

Metal	Tensile Strength lb.	Elastic Limit lb.	Reduction in Area %	Elongation %	Hardness
Gears					
A. Cast steel	60,000	25,000	20	18	140
B. Cast steel, oil tempered	75,000	45,000	40	24	200
C. Forged steel	85,000	55,000	35	22	165
D. Hard alloy steel	95,000	55,000	30	30	...
Pinions					
A. Forged steel; low carbon	55,000	25,000	35	50	150
B. Forged steel; high carbon	85,000	50,000	40	20	200
C. Heat treated (low carbon)	100,000	55,000	40	18	230
D. Heat treated (high carbon)	115,000	82,000	33	15	300
E. Special alloy steel	95,000	55,000	30	30	...

A Rotary Eductor-Type Condenser*

In ENGINEERING NEWS, Oct. 3, 1912, was described the Rees "roturbo" type of centrifugal pump, the novel feature of which was a comparatively large revolving chamber in which water pressure was developed directly without intermediate velocity actions. A modification of this pump has recently appeared in which the essential features of the eductor-type of condenser have been combined to form a rotary jet condenser. Partial sections of one of these machines is shown in the accompanying figure. Water flows from the suction pipe into the revolving cylinder *A*, in the periphery of which are bored the nozzles *D*. The latter are ⅜ or ½ in. in diameter on smaller condensers and ¾ or 1 in. on larger sizes. Water escapes from the pressure drum in jets arranged to impinge in pairs. In this way, the jets break up into a fan of fine spray, but are projected still radial to the shaft and rotate as a whole with the pressure drum. The jets pass across a space *C* into which the steam from an engine or turbine exhaust is allowed to enter through the openings *F*. It is claimed that this construction insures a perfect mixture of steam and water and gives ideal conditions for rapid condensation. Air entrained with the steam is drawn off with the condensate.

The jets as they leave the injection nozzles are not given sufficient velocity to project themselves from the vacuum chamber and to carry with them the entrained air and condensate. Instead, an auxiliary ring, with vanes, is placed around the rotor and the jets are picked up by this to be forced into the casing and out of the discharge line. This auxiliary impeller seems to be equivalent to the mixing cone and the neck or shock zone of the stationary ejector type of condenser. It is claimed that the mechanical ejection of the condensate removes the old difficulties of choking sometimes found with the stationary type.

It is also claimed that the auxiliary exhauster also forms an automatic regulator for fluctuating conditions of steam or vacuum without need for speed regulation. For instance, if the vacuum is reduced below normal the rim blades are practically empty and the water and air mixture is thrown out through the exhausting fan with small help from the vanes. If the vacuum rises above normal, thus exerting a greater backward pressure, the rim blades fill up with water to a greater depth. Because of the extra centrifugal force created with a greater depth of water carried around, a greater exhausting pressure is secured, though running at the same speed as before.

It is claimed that in no invention of this sort has the water been controlled by the pump at both the point of injection to and ejection from the vacuum chamber with opportunity for spraying across the intervening condensing space.

It is claimed that the apparatus can be built in the largest size as a complete condenser without any auxiliary apparatus for extracting air or water. At the same time all the advantages named are claimed for the smaller sizes to be used as air pumps for surface condensers, although it would seem that there was no positive action as by the water slugs in a LeBlanc air pump. When used as an air pump, the same design is used and practically the only difference is in the external casing which is of different shape and has a smaller opening for the entrance of air than is needed for steam.

Low first cost and maintenance, small floor space, and simplicity of construction are claimed to result with this design. In Fig. 2 are shown performance curves of these condensers (as determined from the manufacturer's tests). It is reported that allowance has been made for 3 cu.ft. of free air per minute per 10,000 lb. of condensed steam per hour for reciprocating engines and half of that amount for steam turbines. To use such curves, for instance, with 28-in vacuum, a steam turbine taking 30,000 lb. of steam per hour, and cooling water at 60° F., the diagram is approached from the left-hand side at the ordinate for 28 in. After the intersection with the curve for 60° is reached, the corresponding abscissa is followed to the intersection with the ordinate for 30,000 lb. The curve through here is for 40 hp. or 120,000 gal. per hr. Similar curves are shown for this machine arranged as an air pump.

This pump is a British invention, the rights for which have been acquired in this country by the Manistee Iron Works.

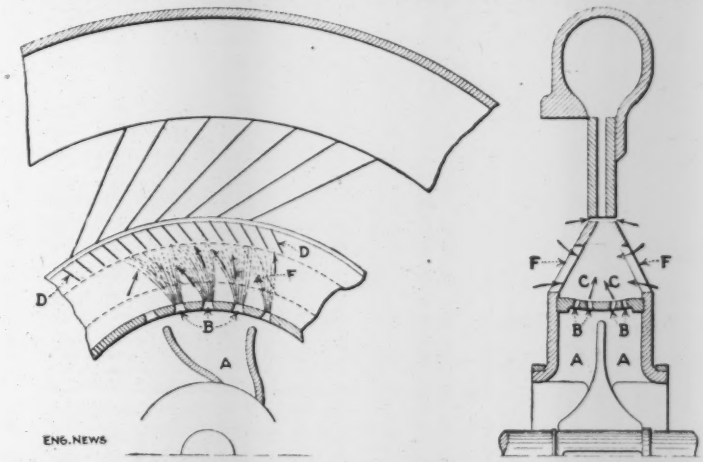

FIG. 1. PARTIAL SECTIONS OF "ROTURBO" ROTARY JET CONDENSER

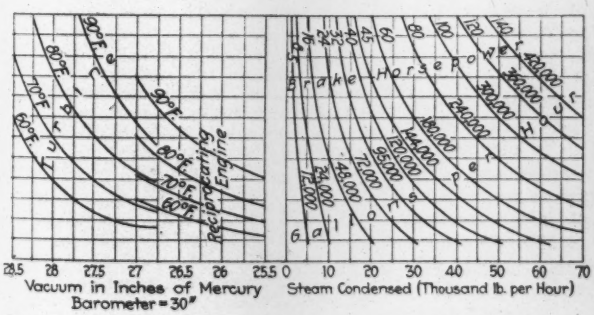

FIG. 2. PERFORMANCE CURVES OF "ROTURBO" PUMP AT A CONDENSER

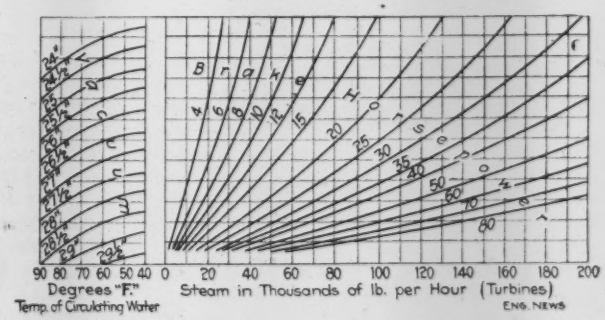

FIG. 3. PERFORMANCE CURVES OF "ROTURBO" AIR PUMP

*Based on information supplied by the Manistee Iron Works Co., Manistee, Mich.

John Munro Whitman

John Munro Whitman, until recently Vice-President of the Chicago & Northwestern Ry., died at Chicago, on Oct. 29, after an active life which included 24 years as an engineer and 31 years in the operating department of railway service. He was born at Eldridge, N. Y., on Aug. 11, 1837, and commenced his engineering career as a rodman on the Illinois Central R.R. in 1856. A summary of his professional career is as follows: rodman on the Illinois Central R.R., 1856-1858; leveler on the enlargement of the Erie Canal, 1858-1860; engineer in charge of construction of the Brunswick & Albany R.R. (in Georgia), 1860-1865; engineer in charge of the construction of the Union Stock Yards, at Chicago, 1866-1867; engineer on the deepening of the Illinois & Michigan Canal, 1867-1869;

JOHN MUNRO WHITMAN
(Dana Hull, Photographer.)

engineer of construction on the Iowa Midland Ry. (now a part of the Chicago & Northwestern Ry.), 1869-1871; engineer and superintendent of the Chicago & Pacific Ry., 1872-1876.

In 1876, the Chicago & Pacific R.R. (now a part of the Chicago, Milwaukee & St. Paul Ry.) got into difficulties, and Mr. Whitman was appointed as Receiver. In 1880, he became Superintendent of the Iowa Division of the Chicago & Northwestern Ry., and remained with that road until his retirement from railway service in 1911. In 1883, he was made General Superintendent of the Chicago, St. Paul, Minneapolis & Omaha Ry. (a part of the C. & N. W. Ry. System), and in 1887 he became General Manager of the Chicago & Northwestern Ry. In 1899 he was made Fourth Vice-President, and in 1906 his title was changed to Vice-President in Charge of Construction. Mr. Whitman resigned in June, 1911, and retired from active life.

Notes from Engineering Schools

RENSSELAER POLYTECHNIC INSTITUTE—New special courses in architecture and in fireproofing of buildings have recently been introduced at this school. They do not form parts of the regular curricula, but are special courses planned originally for graduates of the U. S. Naval Academy who may take post-graduate courses at the Institute. The courses in testing materials and reinforced-concrete construction have also been extended and improved.

Compulsory athletic exercise for freshmen has begun in the new gymnasium, which was presented to the Institute by the class of 1887 and which has just been completed at a cost of $150,000.

SYRACUSE UNIVERSITY—In July, 1911, the New York State Legislature reëstablished the State College of Forestry at Syracuse University, it previously having been located at Cornell University, from 1898 to 1903. This college is, by law, obligated to carry a professional course and to open a ranger school of one or two years' instruction on the college forest in the Adirondacks. Certain educational work is also required to be done about the state, together with such investigations as are necessary for studying problems which may arise in connection with the protection and management of state forests, and with the reforestation of waste areas.

In the spring of 1912, two small adjacent farms south of Syracuse were bought and are being developed as a state forest-experiment station. An experimental nursery has been started here, and there are at present 1,500,000 seedlings and transplanted trees growing under different methods of planting, etc. Some 30 acres of the station land is covered with a second-growth wood lot and here permanent sample areas are being laid out and treated in different ways to see what may be accomplished in rejuvenating wornout wood lots, or in hastening maturity of second-growth timber.

A five-year professional course has been developed and a summer camp of four weeks is to be maintained, in addition to the one and two-year ranger course.

The college has now offered to make plans for the protection and management of timber land and for the reforestation of waste areas. Where the tracts are between 10 and 1000 acres and where there is assurance that the plan developed will be carried out, no expense will be attached to the owner. Where there are smaller areas, the owners will have to pay traveling and sustenance expenses of the college representatives. Owners of small tracts may combine to build up an area of 100 or more acres, so that plans may be secured without cost.

The college is also offering, to all high and preparatory schools of the state, illustrated lectures and demonstrations on forestry. During the spring months a lecturer will be sent out to give practical demonstrations of tree planting. Each school interested will be urged to plant a thousand or two small seedlings on some piece of waste land. The State Conservation Commission, which is working for the protection of the Catskill and Adirondack forests and offers tree seedlings for general sale in the state, has offered each school a thousand or two small trees, ready for planting, at cost plus transportation.

An Explosion of Nitroglycerin at Bradner, Ohio, on Oct. 31, wrecked the factory in which the explosive was being made and killed two of the employees. Press accounts state that about 900 quarts of the liquid were exploded.

In a Butting Collision between a troop train and an express on the Canadian Pacific Railway at Streetsville Junction, Ont., on Oct. 29, two of the soldiers were killed and 25 others badly injured. Press accounts state that the express was standing still at the time of the accident and that the troop train was not traveling over 15 miles an hour, but in spite of this two of the cars were telescoped.

The Tug "Genesee" Overturned at her dock at Jersey City, N. J., on Nov. 3 while taking on coal, and two of the crew who were sleeping below decks at the time of the accident, were drowned. The boat is one of the big 96 ft. steel tugs belonging to the Lehigh Valley R.R. and the sinking is attributed to a sudden movement of the coal in the hold. The boat sank in less than two minutes after the first signs of trouble appeared.

A Boiler Explosion on the U. S. Battleship "Vermont," on the night of Nov. 1, resulted in the death of two stokers and in lesser injuries to four others. At the time of the accident the battleship was at anchor and preparations were being made for the target practice, starting Nov. 2. The press dispatches from Norfolk, Va., state that a header blew out after the fires under this boiler had been banked, and when the steam pressure was below normal.

Vehicles Killed 178 Children in New York City during the first ten months of 1912, according to press reports, and of this number 75% were killed in Manhattan and in Brooklyn where there is the greatest traffic congestion.

Lock Gates Wrecked by a Steamer—On Nov. 1, 1912, the headgates of Lock 13 of the Welland Canal were wrecked by the steamer "Samuel Marshall." The lock is near Thorold, Ont. The collision is charged to high wind prevailing at the time. The steamer was damaged considerably; it was carried down about a quarter mile. New gates were brought from Port Dalhousie, where a stock is kept to provide against accidents such as this one. Several other collisions of steamers with lock gates in the Welland Canal have been recorded in our col-

umns during the present season (Eng. News July 11, 1912, p. 43; Aug. 1, p. 230; Aug. 22, p. 345; Aug. 29, p. 420.)

Foundation Reconstruction in the case of a defective concrete-pile foundation noted in our issue of Sept. 12, 1912, p. 473, was done by placing spread footings. The excavation for these footings was carried about 3 ft. below the point to which the piles had been excavated (i. e. about 8 ft. below pile heads), and here the footings were founded on firm gravel. The excavation thus did not go deep enough to indicate what the condition of the piles might be in the better material below.

The Largest Wireless Station in the world is now being completed and tested out at Arlington, Va. This is one of proposed system of government stations connecting all the strategic naval and military centers of the country. The Arlington plant, including towers, equipment and power station is estimated to have cost in the neighborhood of $1,000,000.

The Hyde Park Accident of March 31, in which the 20th Century Limited on the New York Central line was derailed and about 70 persons injured, has been the subject of investigation by the Interstate Commerce Commission and the blame for the wreck has been placed on faulty condition of the road bed and on the failure of a defective rail. The report states further that this dangerous combination exists to a greater extent than is generally believed, and that high speed operation contributes a third element of danger, because rails and road bed which will stand up under moderate speeds are unable to stand the increased strains from increased speed of trains.

The Anthracite Mining Industry of Pennsylvania has become concentrated into strong and relatively few units, according to a bulletin of the U. S. Geological Survey. It is stated that in 1911 nearly 75% of the mines were producers of more than 100,000 tons each, and that 97% of the total production of hard coal was from this group of mines.

The Public Drinking Cup is now under the ban of the Federal Government. The Secretary of the Treasury has issued an order forbidding interstate carriers to provide drinking cups or glasses for common use on railway trains and vessels and in waiting rooms of stations. Several of the states have passed laws forbidding the use of common cups, or compelling the furnishing of individual cups, but there has never been any specific national legislation on the subject. The Secretary of the Treasury finds authority for the order in a law giving him the right to provide regulations affecting interstate commerce in certain particulars, which was passed in 1893.

For the Elimination of Grade Crossings on railroads within the limits of the City of New York $1,500,000 has been asked for by the Public Service Commission for the First District, State of New York. Under the law, the cost of the elimination of grade crossings is borne one-half by the railroad company, one-quarter by the city and one-quarter by the state, but no proceedings can be taken by the Commission towards elimination until the state shall have appropriated its share.

Elimination work to cost about $2,000,000 is now underway at Flushing on the Long Island R.R. This was made possible by an appropriation of $500,000 by the state in response to requests made by the Commission in 1909 and 1910. Additional elimination work to cost $1,400,000 would now be in progress had it not been for the veto by Governor Dix of an appropriation of $350,000 made by the last legislature.

The total number of crossings, public and private, within the city is 488, of which 205 are in Queens, 117 in Richmond, 103 in Manhattan, 58 in Brooklyn, and 5 in the Bronx. With the elimination work already ordered by the Commission and that going on as a result of agreements between the city and railroad companies, this total will be reduced by 48—32 being in Queens, 10 in Brooklyn, 4 in the Bronx, and 2 in Richmond. Many of the existing grade crossings are danger points at which persons are killed or injured every year. The Commission's figures show that for the four years from 1908 to 1911 inclusive, 90 persons were killed and 136 injured at such crossings. Even with a liberal appropriation, it is estimated that it will take several years to complete the necessary work.

Until the Public Service Commission was created, the elimination of grade crossings lagged. For 10 years prior to 1907, when the Commission was created, the State of New York made total appropriations aggregating $1,478,000, but out of this entire amount only $9720 was expended within the limits of New York City. This item was for the elimination of a crossing in Van Courtlandt Park on the Putnam Division of the New York Central & Hudson River R.R.

The Effect of Floods and a severe winter on the earnings of a railway is indicated in the recent annual report of the Chicago Rock Island & Pacific R.R. The president of the road, in presenting the report, said:

> In common with other railroads the gross revenue of this company decreased and the expenses of operation increased, as compared with the preceding fiscal year. The almost unparalleled weather conditions in the winter of 1911-12 and the extraordinary flood conditions in the spring of 1912, during which latter period some forty miles of the company's tracks were under water for more than two weeks, made both for an increase in expenses and a decrease in earnings.

A New Record for Deep Sea Sounding has been made by the German survey ship "Planet," according to the "Geographical Journal." This ship obtained a depth of 9780 m. (5348 fathoms, 32,088 ft., or 6.08 mi.), about 40 nautical miles east of northern Mindanao, in the Philippines. It is stated that the sounding was obtained under conditions which permit the fullest confidence in its accuracy, while a determination of bottom temperature and a sample of the seabottom was secured.

The Corrugated-Hull Ship "Monitoria," which was described in Engineering News, June 16, 1910, p. 701, is proving very successful in practice, according to Capt. G. S. MacIlwaine, R. N., in a recent address before the Royal United Service Institution, in London. He said that after a long voyage on the vessel he had concluded that the corrugated ship is stronger, would be better able to resist collision, would be more easily repaired if damaged, and was steadier and more readily handled than the ordinary hull. He observed that there was less vibration and greater speed for the same fuel consumption, the latter being probably due to the fact that the corrugations lead the water to the propeller in such a manner as to reduce slip, which with a corrugated hull about 2%, as compared to 13% with an ordinary hull.

Two Floating Docks, each with a lifting capacity of 32,000 tons, have recently been completed for the British Navy by Cammell, Laird & Co., of Birkenhead, England. These docks are 680 ft. in length over all and 124 ft. in width. One of the docks is located at Portsmouth and the other at Sheerness.

Personals

Mr. M. H. Cahill, Division Superintendent of the Baltimore & Ohio R.R., Newark, Ohio, has resigned.

Mr. L. A. Magraw, Assoc. Am. Inst. E.E., Chief Engineer of the Central Georgia Power Co., Macon, Ga., was married on Nov. 6 to Miss Sarah de S. Davis of Charlotte, N. C.

Mr. E. W. Batchelder, Division Superintendent of the Erie R.R., at Meadville, Penn., has been appointed Assistant General Superintendent with headquarters at Marion, Ohio.

Mr. E. N. Todd has been appointed Civil Engineer and Superintendent of Construction, Quartermasters Department U. S. A., in charge of construction work at Fort McPherson, Atlanta, Ga.

Mr. P. A. Hoffman, formerly Sales Manager of the New York branch of the B. F. Sturtevant Co., Boston, Mass. is now associated with Evans, Almirall & Co., Contracting Engineers, New York City.

Mr. Joseph Ramsey, Jr., M. Am. Soc. C.E., former President of the Wabash R.R., and now President of the Ann Arbor R.R., is promoting another railway in Ohio known as the Lorain, Ashland & Southern R.R.

Mr. Lewis I. Birdsall, formerly Superintendent of the water filtration plant of the city of Rock Island, Ill., has been appointed Superintendent of the new 39,000,000 gal. water-purification works at Minneapolis, Minn., described in our issue of June 27, 1912.

Mr. C. A. Dunham, Signal Engineer of the Great Northern Ry., has been appointed Signal Engineer of the Grand Trunk Ry. System, this being a new office created Nov. 1. His headquarters will be at Montreal, Canada, and he will report to the Chief Engineer.

Mr. H. R. Burroughs, Assoc. M. Am. Soc. C.E., Principal Assistant Engineer with Mr. S. C. Weiskopf, M. Am. Soc. C.E., Consulting Engineer, 68 William St., New York City, has been admitted to junior partnership, and the business will now be conducted under the firm name Weiskopf & Burroughs.

Mr. R. W. Sharpe, Construction Superintendent with the Pittsburgh Filter Co., Pittsburgh, Penn., has been appointed Superintendent of the water filtration plant of the city of Rock Island, Ill., succeeding Mr. Lewis I. Birdsall, whose resignation is noted elsewhere in these columns.

Mr. C. H. Hix, whose resignation as Vice-President and General Manager of the Seaboard Air Line Ry. was noted in our issue of last week, has been elected President of the Norfolk Southern Ry., with offices in Norfolk, Va., succeeding Mr. E. T. Lamb, whose resignation was noted in our issue of Aug. 1, 1912.

Mr. G. W. Buchholz, for the past four years Chief Engineer of the Northeastern Construction Co., has resigned to enter private practice as a contracting and consulting engineer, with offices at 23 East 26th St., New York City. Mr. Buchholz is a son of the late Charles W. Buchholz, M. Am. Soc. C. E., for many years Chief Engineer of the Erie R.R.

Mr. Franklin W. Cram has resigned as President of the Bangor & Aroostook R.R., at Bangor, Maine. Mr. Cram began railway work in 1860 as a freight porter on the Maine Central R.R., and has been President of the Bangor & Aroostook R.R. since 1900. Mr. Arthur Holland, of Concord, Mass., succeeds Mr. Cram as President.

Mr. J. T. Dickerson, Assoc. M. Am. Soc. C.E., Sales Engineer of the Strauss Bascule Bridge Co., at 30 Church St., New York City, has been promoted to be Contracting Engineer, with headquarters at the company's general offices in Chicago, Ill. The New York office will be in charge of Mr. J. I. Vincent, M. Am. Soc. C.E., for a number of years Eastern representative of the Sherzer Rolling Lift Bridge Co., at New York City. Mr. P. L. Kaufman, at present with the Chicago office, will become Pacific Coast representative with headquarters at Seattle, Wash.

Obituary

Horace W. Clarke, former Vice-President and General Manager of the Denver & Rio Grande R.R., died at his home in Frederick, Md., Nov. 1. Mr. Clarke was born at Cumberland, Md., on Sept. 27, 1854, and at 18 years of age he entered the railway service as an apprentice in the machine shops of the Northern Central R.R., in Baltimore, Md. In 1876 he became a clerk in the drafting office of the Illinois Central R.R., and the following year gained some knowledge of construction work as a section foreman and conductor of a construction train on the Chicago, St. Louis & New Orleans R.R. From this position he was promoted to Trainmaster, and in 1883 he returned to the Illinois Central R.R. as Division Superintendent. From 1890 to 1902 he was Division Superintendent at Cairo, Ill., of the Mobile & Ohio R.R. Later he became Superintendent of Transportation of the same railway, and a few years ago went to the Denver & Rio Grande R.R., as General Manager. He retired from active work about a year ago to enjoy a well-earned rest on his farm in Maryland.

Engineering Societies

COMING MEETINGS

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS
Nov. 12-15. Annual convention at Dallas, Texas. Secy., A. P. Folwell, 50 Union Square, New York.

RAILWAY DEVELOPMENT ASSOCIATION.
Nov. 17. Annual meeting at Cincinnati, Ohio. Secy., W. Nicholson, K. C. So. Ry., Kansas City, Mo.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 19. Annual convention at Washington, D. C. Secy., W. H. Connolly, Washington, D. C.

AMERICAN CIVIC ASSOCIATION.
Nov. 19-22. Annual convention at Baltimore, Md. Secy., Richard B. Watrous, Union Trust Bldg., Washington, D. C.

AMERICAN RAILWAY ASSOCIATION.
Nov. 20. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 75 Church St., New York.

NATIONAL FOUNDERS ASSOCIATION.
Nov. 20-21. Annual convention at New York, N. Y. Secy., J. M. Taylor, 29 So. La Salle St., Chicago, Ill.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 21-22. Annual meeting at New York, N. Y. Secy., D. H. Cox, 29 W. 39th St., New York.

AMERICAN MINING CONGRESS.
Nov. 25-28. Annual convention at Spokane, Wash. Secy., J. F. Callbreath, Denver, Colo.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 2-3. Annual meeting at New York City. Secy., W. H. Ross, 154 Nassau St., New York.

NATIONAL COMMERCIAL GAS ASSOCIATION.
Dec. 2-5. Annual meeting at Atlanta, Ga. Secy., Louis Stotz, 29 W. 39th St., New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Dec. 3-6. Annual convention at Cincinnati, Ohio. Secy., E. L. Powers, 150 Nassau St., New York.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 3-6. Annual meeting at New York City. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 4-6. Annual meeting at Detroit, Mich. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 5-7. Annual convention at Philadelphia, Penn. Secy., C. A. Prosser, 105 E. 22d St., New York.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 9-12. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Penn.

NATIONAL ASSOCIATION OF CEMENT USERS.
Dec. 10-14. Annual convention at Pittsburgh, Penn. Secy., E. E. Krauss, Harrison Bldg., Philadelphia, Penn.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 26-28. Annual meeting at Chicago, Ill. Secy., C. O. Reed, Urbana, Ill.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 30-Jan. 6. Annual meeting at Cleveland, Ohio. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

New York Railroad Club—The annual meeting of the Club will be held, on Nov. 15, and Gilbert E. Ryder will give a paper on "The Locomotive Superheater and Some of Its Effects on the Cost of Railway Operation." H. D. Vought, Secy., 95 Liberty St., New York.

New England Water Works Association—The November meeting of the Association is to be held in Boston, Mass., on Nov. 13. A paper entitled, "Some Difficulties Encountered in Tunnel and Subway Construction" will be presented by F. I. Winslow and discussion will be held on the topic, "Paint for Standpipes and Methods of Applying."

Pacific Northwest Society of Engineers—The Society's annual meeting will be held in Seattle, Wash., on Jan. 4, at which time officers for the ensuing year will be elected.

American Institute of Electrical Engineers—The general topic of the meeting on Nov. 8 in New York City, will be "The Electrification of Steel Mills." A paper on "Power Requirements of Steel Mills," by Wilfred Sykes, and one on "The Economical Speed Control of Induction Motors for Rolling Mills," by F. W. Meyer and Wilfred Sykes will be read.

American Society of Mechanical Engineers—At the annual meeting, to be held in New York City on Dec. 3-6, ten sessions will be arranged with papers grouped to form symposiums on the various subjects. The following are among the important papers to be given: "The Principles of Valuing Property," by H. K. Rowell; "Increase of Bore of High Speed Wheels by Centrifugal Stresses," by S. A. M[illegible]; "Investigation of Efficiency of Worm Gearing for Automobile Transmission" by W. H. Kenerson; "Measurement of Air in Fan Work," by C. H. Treat; "The Baltimore Sewerage Pump Valve," by A. F. Nagle; "The Vauclain Drill," by A. C. Vauclain and H. V. Wille; "Tests of a 1000 h.p., 24 tubes High, B. & W. Boiler," by B. N. Bump; "The V-Notch Weir Method of Measurement," by D. R. Yarnall; "Dimensions of Boiler Chimneys for Crude Oil," by C. R. Weymouth; "Air in Surface Condensation," by G. A. Orrok; "The Centrifugal Blower for High Pressures," by H. F. Schmidt; and "Measurement of Natural Gas," by T. R. Weymouth.

At a regular meeting in New York on Nov. 12 a paper on "Measuring Efficiency in Manufacturing" will be given by S. B. Passans.

American Society of Civil Engineers—The list of nominees for the offices to be filled Jan. 15, 1913, has been prepared by the Nominating Committee, as follows:

President, George F. Swain, of Harvard University.

Vice Presidents; J. Waldo Smith, New York City and Charles H. Rust, Victoria, B. C.

Treasurer, John F. Wallace, New York City.

Directors (to serve three years, one-third of the total board); H. W. Hodge, N. Y.; J. H. Edwards, N. J.; Leonard Metcalf, Mass.; H. R. Leonard, Penn.; E. H. Connor, Kansas; S. H. Hedges, Wash.

On the program for the meeting of Nov. 6, in New York City, were the following papers: The Flood of March 22, 1912, at Pittsburgh, Penn.," by K. C. Grant; and "State and National Water Laws, with Detailed Statement of the Oregon System of Water Titles," by J. H. Lewis.

Ohio Society of Mechanical Electrical and Steam Engineers—The 11th annual meeting of the Society will take place on Nov. 21-23, at Akron, Ohio, and papers on the following subjects will be given; "A System of Gas Engine Governing," by G. S. Cooper; "The Lentz System Applied to Steam Engines," by Siegfried Rosenzweig; and "The Manufacture of Tin Plates," by E. W. Patton. Numerous inspection trips to the points of engineering interest in and near Akron, have been arranged. F. E. Sanborn, Secy., Ohio State University, Columbus, Ohio.

National Association of Cement Users—The ninth annual convention of the National Association of Cement Users will be held at the Fort Pitt Hotel, Pittsburgh, Penn., Dec. 10-14, inclusive, the convention proper opening on Tuesday evening, Dec. 10, and closing on Friday evening, Dec. 13, with one session Tuesday, two sessions Wednesday, two sessions Thursday and a banquet Thursday night, and three sessions Friday. Saturday will be devoted to a visit to the United States Government Testing Laboratories where tests of concrete beams and columns will be carried on for the benefit of the visitors. This is a materially shorter time for the program than has been the practice in previous conventions of this Association; that is, there are eight sessions scheduled to cover four days instead of nine sessions spread over six days as has hitherto been the practice, a reform which all who have attended the conventions will be glad to see. The regular annual Cement Show will be held in Pittsburgh about the same time, overlapping the time of the convention.